

SOIL SURVEY OF

# Osborne County, Kansas



United States Department of Agriculture  
Soil Conservation Service

In cooperation with  
Kansas Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1965-70. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Osborne County Conservation District.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

## HOW TO USE THIS SOIL SURVEY

**T**HIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and windbreaks; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

### Locating Soils

All the soils of Osborne County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

### Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and lists the windbreak suitability group and range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the

same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

*Farmers and those who work with farmers* can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units, the range sites, and the windbreak suitability groups.

*Foresters and others* can refer to the section "Management of Soils for Windbreaks," where the soils of the county are grouped according to their suitability for trees.

*Game managers and others* can find information about soils and wildlife in the section "Use of Soils for Fish and Wildlife Habitat."

*Ranchers and others* can find, under "Management of Soils for Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

*Community planners and others* can read about soil properties that affect the choice of sites for dwellings, industrial buildings, and recreation areas in the sections "Use of Soils for Recreation Facilities" and "Engineering Uses of Soils."

*Engineers and builders* can find, under "Engineering Uses of Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

*Scientists and others* can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

*Newcomers to Osborne County* may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the County."



## Contents

<b>Summary of tables</b> .....	ii	Nc—New Cambria silty clay .....	22
<b>How this survey was made</b> .....	1	Nd—New Cambria silty clay, frequently flooded .....	22
<b>General soil map</b> .....	2	Nibson series .....	22
1. Harney-Mento-Brownell association ..	2	Nx—Nibson complex .....	23
2. Armo-Heizer-Bogue association .....	3	Nuckolls series .....	23
3. Harney-Nuckolls association .....	5	Roxbury series .....	24
4. Hord-Roxbury-McCook association ....	6	Ro—Roxbury silt loam .....	24
5. Harney-Corinth-Nibson association ....	7	Rp—Roxbury silt loam, channeled .....	24
<b>Descriptions of the soils</b> .....	8	Rr—Roxbury complex .....	24
Alluvial land .....	9	Timken series .....	24
Aa—Alluvial land, loamy .....	9	Tb—Timken-Bogue clays .....	25
Ab—Alluvial land, mixed .....	10	Tm—Timken-Shale outcrop complex .....	25
Armo series .....	10	Tobin series .....	25
Ar—Armo silt loam, 3 to 7 percent slopes ..	11	Tr—Tobin and Roxbury silt loams .....	25
As—Armo silt loam, 3 to 7 percent slopes, eroded .....	11	Wakeen series .....	26
Ax—Armo-Bogue complex .....	11	Wm—Wakeen-Mento complex, 3 to 8 per- cent slopes .....	26
Bogue series .....	12	<b>Use and management of the soils</b> .....	26
Bo—Bogue clay, 3 to 15 percent slopes ....	12	Management of soils for dryfarmed crops ..	26
Brownell series .....	12	Managment of soils for irrigated crops ....	27
Bw—Brownell-Wakeen complex .....	13	Capability grouping .....	27
Corinth series .....	13	Predicted yields .....	29
Co—Corinth silty clay loam, 3 to 7 percent slopes .....	14	Management of soils for range .....	30
Cr—Corinth silty clay loam, 7 to 15 percent slopes .....	14	Range sites and condition classes .....	30
Detroit series .....	14	Descriptions of range sites .....	31
De—Detroit silty clay loam .....	15	Management of soils for windbreaks .....	33
Harney series .....	15	Windbreak suitability groups .....	33
Ha—Harney silt loam, 0 to 1 percent slopes..	16	Use of soils for fish and wildlife habitat ....	35
Hb—Harney silt loam, 1 to 3 percent slopes..	16	Use of soils for recreation facilities .....	35
Hc—Harney silt loam, 3 to 7 percent slopes..	16	Engineering uses of soils .....	36
Hd—Harney silty clay loam, 2 to 7 percent slopes, eroded .....	16	Engineering classification systems .....	39
He—Harney-Mento complex, 1 to 3 percent slopes .....	16	Engineering test data .....	39
Hm—Harney-Mento complex, 3 to 7 percent slopes .....	16	Estimated engineering properties .....	39
Hn—Harney-Nuckolls complex, 3 to 8 per- cent slopes .....	17	Engineering interpretations of soils .....	44
Heizer series .....	17	<b>Formation and classification of the soils</b> .....	53
Hx—Heizer-Brownell complex .....	18	Factors of soil formation .....	53
Hord series .....	19	Parent material .....	54
Hx—Hord silt loam .....	19	Climate .....	55
Inavale series .....	19	Plant and animal life .....	55
In—Inavale loamy fine sand .....	20	Relief .....	55
McCook series .....	20	Time .....	55
Ma—McCook silt loam .....	20	Classification of the soils .....	55
Mento series .....	21	<b>General nature of the county</b> .....	56
Munjoy series .....	21	History and development .....	57
Mc—Munjoy-McCook complex .....	21	Physiography, relief, and drainage .....	57
New Cambria series .....	22	Climate .....	57
		Water supply .....	58
		Farming .....	58
		<b>Literature cited</b> .....	59
		<b>Glossary</b> .....	59
		<b>Guide to mapping units</b> .....	Following
			60

## Summary of Tables

Descriptions of the Soils		Engineering test data (Table 6) -----	40
Approximate acreage and proportionate extent of the soils (Table 1) -----	8	Estimated soil properties significant in engineering (Table 7) -----	42
Use and Management of the Soils		Interpretations of engineering properties of the soils (Table 8) -----	46
Predicted average yields per acre (Table 2) -----	30	Formation and Classification of the Soils	
Suitability of the soils for windbreaks (Table 3) -----	34	Classification of soil series (Table 9) -----	56
Potential of soil associations for producing habitat for wildlife (Table 4) -----	35	General Nature of the County	
Recreational development (Table 5) -----	37	Temperature and precipitation (Table 10) -	57
		Freeze dates in spring and fall (Table 11) -	58

# SOIL SURVEY OF OSBORNE COUNTY, KANSAS

BY EDWARD F. FLEMING, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN  
COOPERATION WITH THE KANSAS AGRICULTURAL EXPERIMENT STATION

OSBORNE COUNTY is in the north-central part of Kansas (fig. 1). It has an area of about 574,720 acres or 898 square miles. Osborne, the county seat, is in the north-central part of the county.

Farming and related services are important in Osborne County. Wheat, grain and forage sorghum, corn, and alfalfa are the main crops. Raising beef cattle is the major livestock industry, but raising hogs is important.

In the valleys of the North and South Forks of the Solomon River, irrigation has been developed by the Kirwin and Webster Irrigation Districts. Wells and the rivers in the two valleys also provide irrigation water. Range occupies about 40 percent of the county.

Oil is produced in the southwest corner of Osborne County near Natoma. Small industries are scattered throughout the county.

## How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Osborne County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

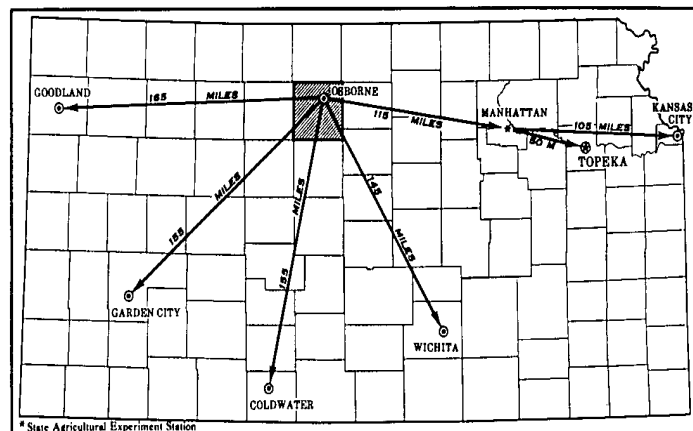


Figure 1.—Location of Osborne County in Kansas.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Harney and Hord, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Harney silt loam, 1 to 3 percent slopes, is one of several phases within the Harney series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Osborne County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more

dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Harney-Mento complex, 1 to 3 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Tobin and Roxbury silt loams is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Alluvial land, loamy, is a land type in this county.

While a soil survey is in progress, soil scientists take samples of soils needed for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consulting farmers, agronomists, engineers, and others; then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

## General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Osborne County. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association can occur in another but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a

wooded tract, or a wildlife area or in planning engineering works, recreation facilities, and community developments. It is not a suitable map for planning the management of a farm or field or for selecting a site for a road or building or other structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The five soil associations in Osborne County are described in the following pages.

### 1. Harney-Mento-Brownell association

*Deep and moderately deep, nearly level to steep, loamy soils formed in loess and material weathered from soft limestone; on uplands*

This association is above the limestone hills on broad uplands. The landscape is mostly nearly level to sloping and is dissected by shallow entrenched drainageways (fig. 2). There are, however, steep areas along the larger drainageways. The association consists mainly of a mantle of loess over soft limestone and limy shale. Small low hills of soft limestone and limy shale are widely scattered throughout.

This association covers about 24 percent of the county. Harney soils make up about 45 percent of the association; Mento soils, 14 percent; Brownell soils, 8 percent; and minor soils, 33 percent.

Most of the Harney soils are nearly level to sloping and are in broad areas between drainageways. These soils are deep and have a surface layer of silt loam about 10 inches thick. The subsoil is friable silty clay loam about 20 inches thick. The substratum is silt loam. Harney soils formed in deep loess. They are well drained and have moderately slow permeability.

The Mento soils are gently sloping to sloping. They are in small areas intermingled with the Harney soils and are close to the Brownell soils. Mento soils are deep and have a surface layer of silty clay loam about 6 inches thick. They have a subsoil of firm silty clay loam about 26 inches thick. The upper part of the subsoil is moderately high in sodium. The substratum is silty clay loam. Mento soils formed in moderately deep loess over soft limestone. They are well drained and have slow permeability.

The Brownell soils are strongly sloping to steep and are on side slopes of drainageways and low hills. They are moderately deep and have a surface layer of loam about 8 inches thick. The subsoil is friable gravelly loam about 7 inches thick. The substratum is channery loam, and it grades into the underlying soft limestone bedrock at a depth of about 27 inches. Brownell soils formed in material weathered from limestone. They are well drained and have moderate permeability above the bedrock.

The minor soils in this association are the Armo, Roxbury, Tobin, and Wakeen soils. The Armo and Wakeen soils formed on uplands in material weathered from soft limestone. Roxbury and Tobin soils are on flood plains and narrow stream terraces.

Most of this association is cultivated and is suited to all crops commonly grown in the county. The steeper soils are used for range. The main concerns in managing the cultivated areas are controlling erosion, conserving moisture, and maintaining soil tilth and

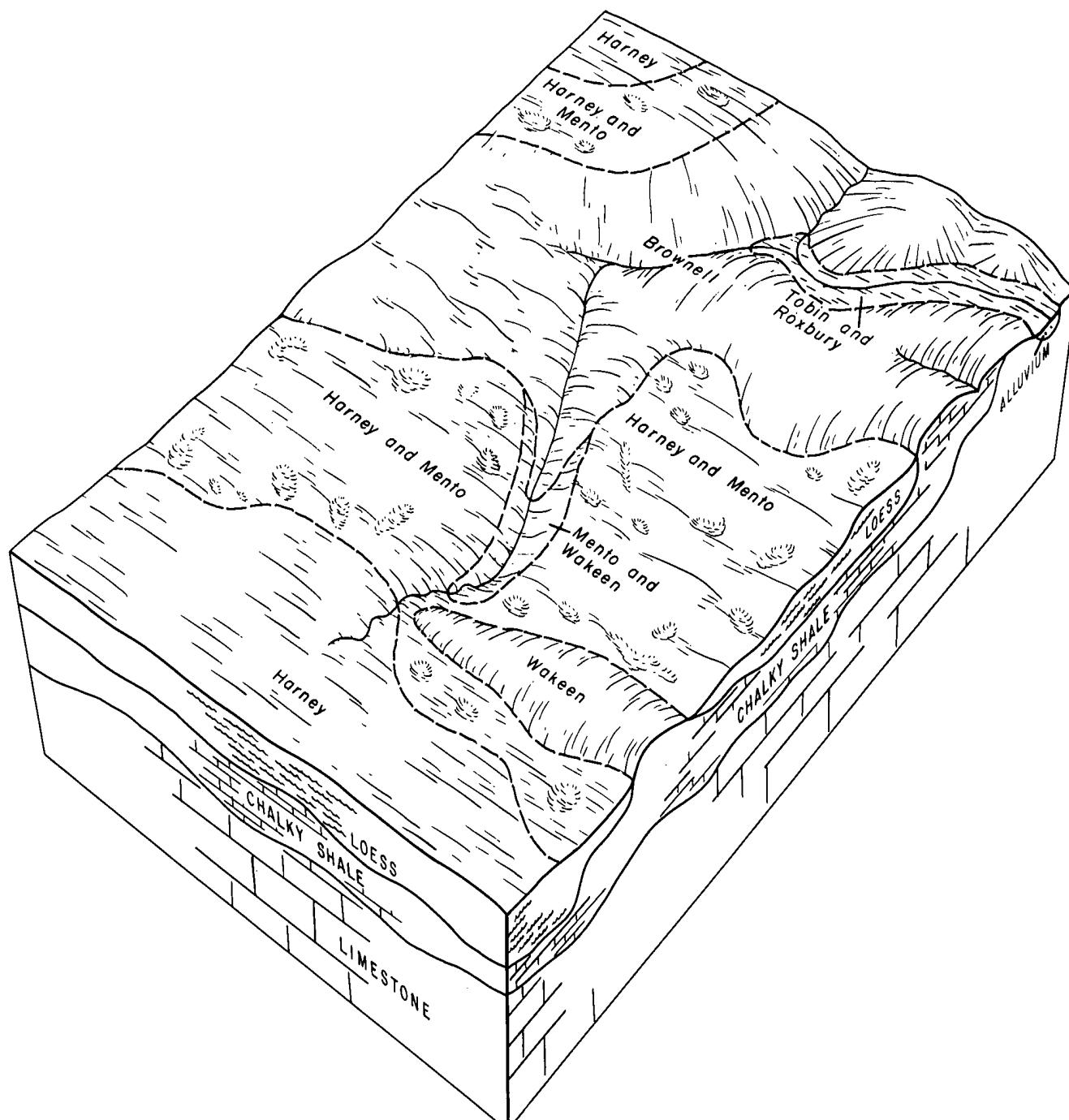


Figure 2.—Representative pattern of the soils in the Harney-Mento-Brownell association in the western part of the county.

fertility. Proper range management is the main concern in the uncultivated areas.

## 2. Armo-Heizer-Bogue association

*Deep to shallow, sloping to steep, loamy and clayey soils formed in material weathered from limestone and shale; on uplands*

This association is on prominent limestone and shale hills and in steep broken areas throughout the county. The landscape is one of ridgetops, side slopes, and small, steep-sided drainageways (fig. 3).

This association covers about 26 percent of the

county. Armo soils make up about 30 percent of the association; Heizer soils, 16 percent; Bogue soils, 15 percent; and minor soils, 39 percent.

The Armo soils are sloping to moderately steep and are on broken, colluvial foot slopes adjacent to limestone hills. They are deep and calcareous and contain numerous chips and pebbles of limestone. The surface layer is silt loam about 11 inches thick. The subsoil is friable light silty clay loam about 17 inches thick. The substratum is silt loam. Armo soils are well drained and have moderate permeability.

The Heizer soils are strongly sloping to steep and are on the limestone hills. These soils are shallow and

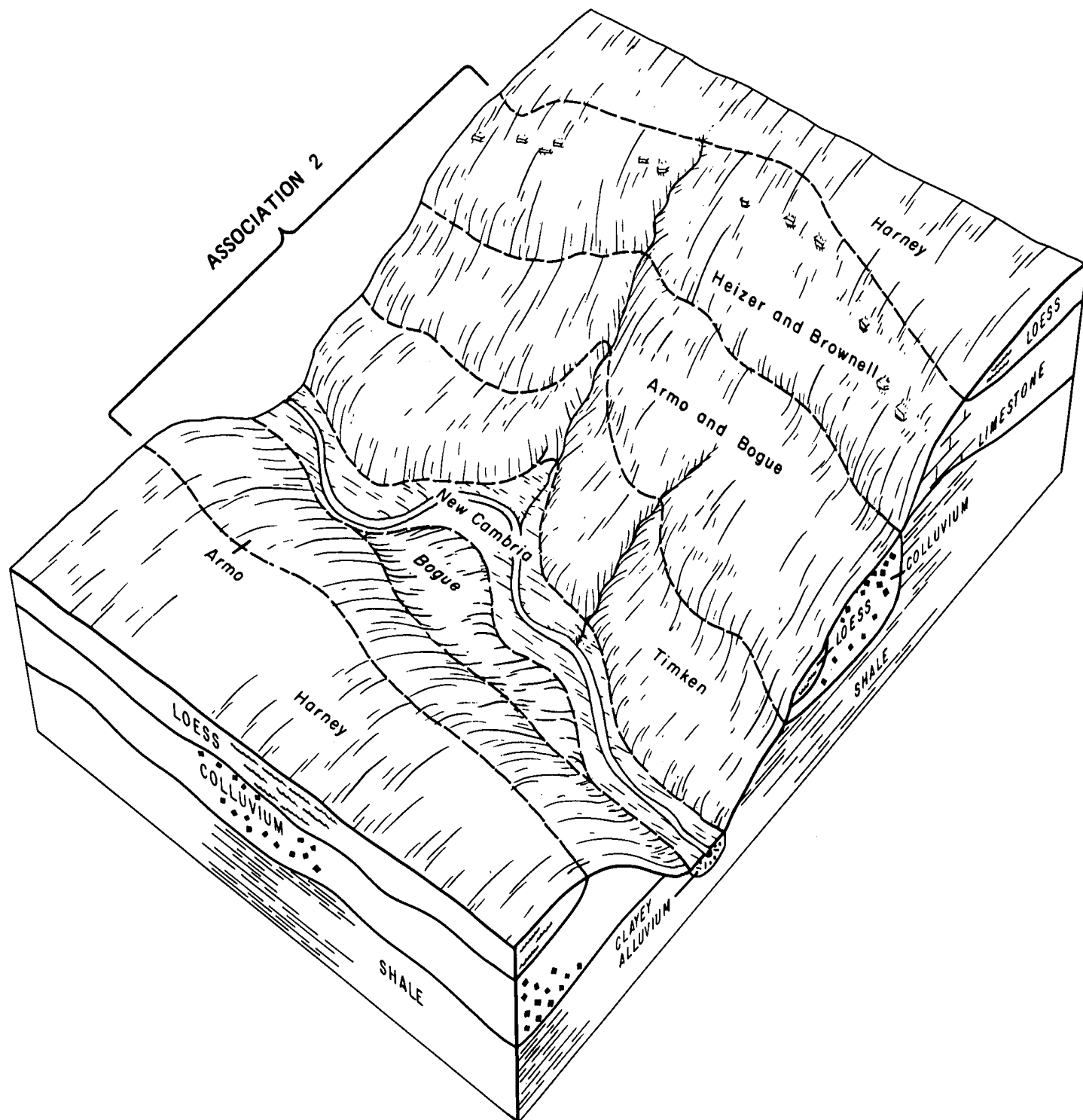


Figure 3.—Representative pattern of the soils in the Armo-Heizer-Bogue association in the central part of the county.

have a surface layer of gravelly loam, about 9 inches thick, that contains chips and pebbles of limestone. The layer below that is friable channery loam that contains many fragments of limestone. This layer overlies massive limestone at a depth of about 16 inches. Heizer soils are somewhat excessively drained and have moderate permeability above the limestone.

The Bogue soils are sloping to steep and are on broken foot slopes and in drainageways adjacent to the limestone hills. They are moderately deep and have a

surface layer of clay about 8 inches thick. The subsoil is very firm clay about 12 inches thick. The substratum is clay that contains many small fragments of shale. The underlying shale is at a depth of about 33 inches. Bogue soils are moderately well drained and have very slow permeability.

The minor soils in this association are the Brownell, Harney, Mento, New Cambria, and Timken soils. Brownell soils are on ridgetops and are similar to Heizer soils, but they are deeper over unweathered



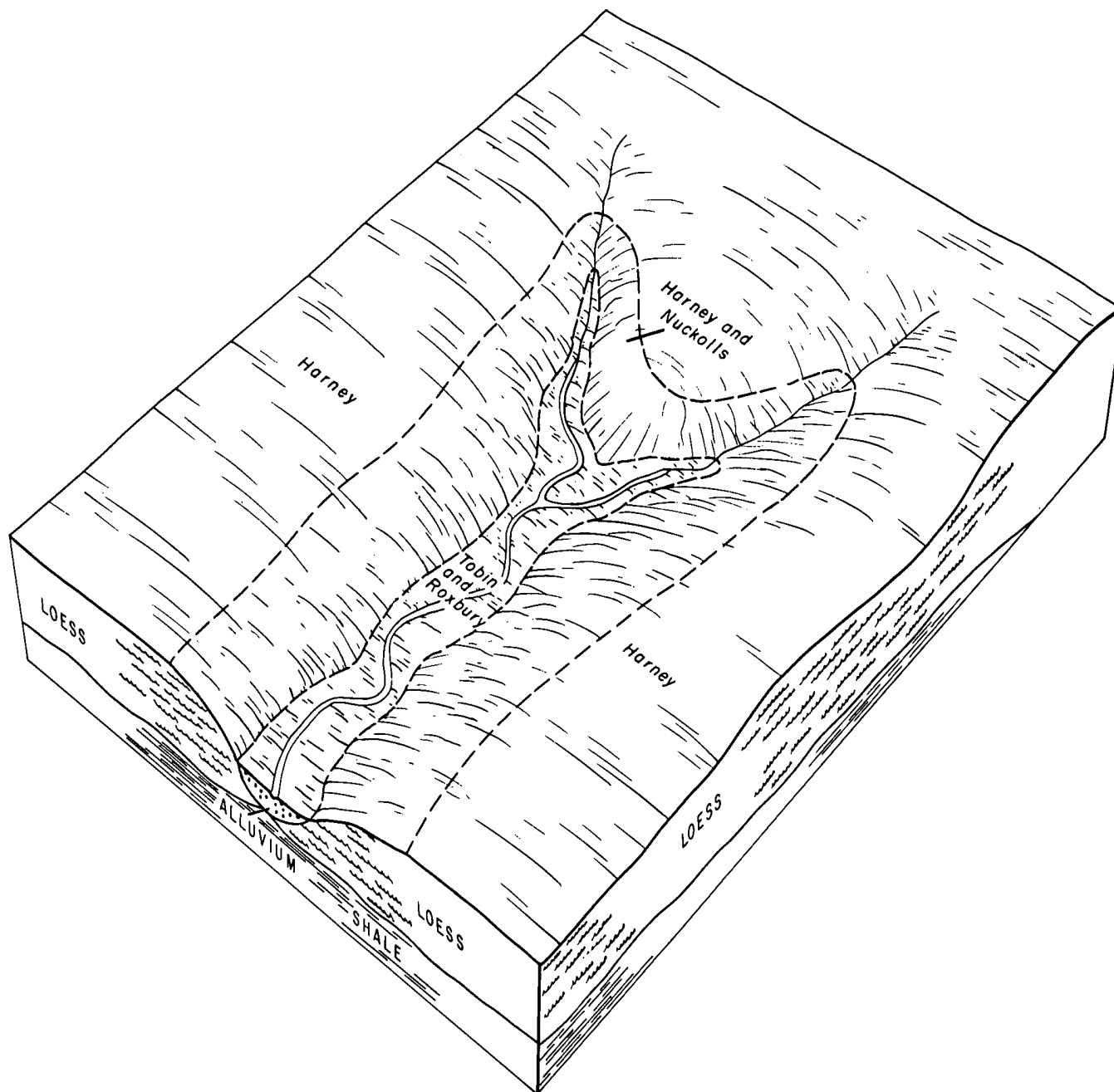


Figure 4.—Representative pattern of the soils in the Harney-Nuckolls association in the eastern part of the county.

limestone. Harney and Mento soils are less sloping than the major soils in this association; they occupy areas where the loess is thicker. New Cambria soils are on the flood plains and terraces of streams. Timken soils are similar to Bogue soils but are less deep and more sloping.

Most of this association is used for range. Good range management and development of water resources are needed in the area.

### 3. Harney-Nuckolls association

*Deep, nearly level to sloping, loamy soils formed in loess; on uplands*

This association is on broad uplands below the lime-

stone hills. The landscape is mostly nearly level to gently sloping but is dissected by many drainageways that are sloping and shallowly entrenched (fig. 4).

This association covers about 26 percent of the county. Harney soils make up about 60 percent of the association; Nuckolls soils, 25 percent; and minor soils, 15 percent.

Most of the Harney soils are nearly level to sloping and are in broad areas between drainageways. These soils are deep and have a surface layer of silt loam about 10 inches thick. The subsoil is friable silty clay loam about 20 inches thick. The substratum is silt loam. Harney soils are well drained and have moderately slow permeability.

The Nuckolls soils are gently sloping and are on the

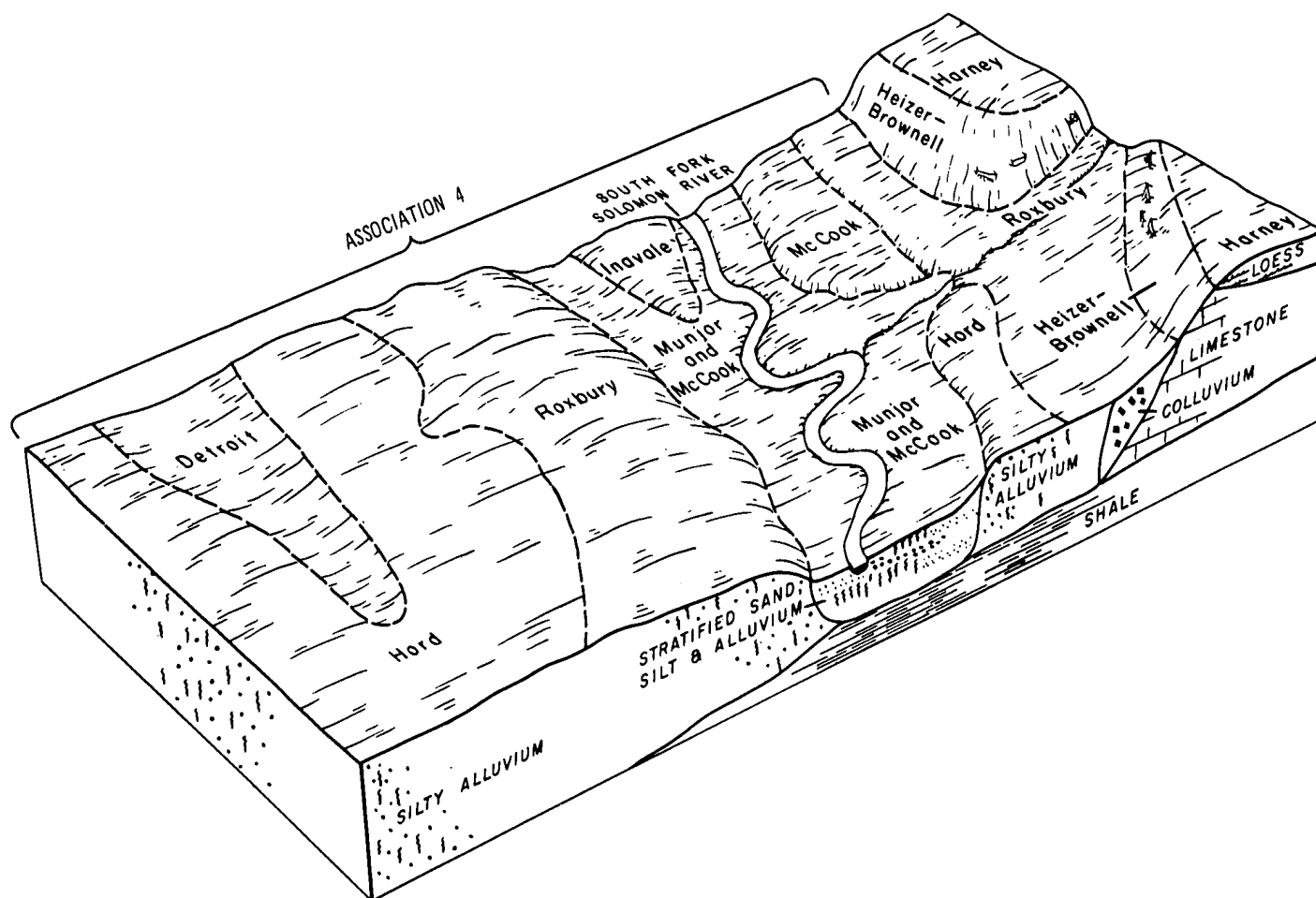


Figure 5.—Representative pattern of the soils in the Hord-Roxbury-McCook association in the Solomon River valley.

side slopes of upland drainageways. They have a surface layer of silt loam about 11 inches thick. The subsoil is friable light silty clay loam about 24 inches thick. The substratum is silt loam. Nuckolls soils are well drained and have moderate permeability.

The minor soils in this association are the Armo, Tobin, and Roxbury soils. Armo soils are in places where drainage water from the hills of limestone, loess, and shale has deposited gravelly and silty material. Tobin and Roxbury soils are deep, dark, and friable; they are on the flood plains of upland drainageways.

Most of this association is cultivated. Wheat and grain sorghum are well suited to the soils. The main concerns in managing the cultivated areas are controlling water erosion, conserving moisture, and maintaining soil tilth and fertility.

#### 4. Hord-Roxbury-McCook association

*Deep, nearly level to gently undulating and sloping, loamy soils formed in alluvium; on flood plains and terraces*

This association is in the valleys of the North and South Forks of the Solomon River and in valleys of the larger drainageways (fig. 5).

This association covers about 13 percent of the county. Hord soils make up 35 percent of the associa-

tion; Roxbury soils, 33 percent; McCook soils, 16 percent; and minor soils, 16 percent.

The Hord soils are nearly level and occur throughout the association. They formed in medium-textured alluvial sediment on high terraces. These soils have a surface layer of silt loam about 15 inches thick. The subsoil is friable light silty clay loam about 17 inches thick. The substratum is silt loam. Hord soils are well drained and have moderate permeability.

The Roxbury soils are nearly level to sloping. They also formed in medium-textured alluvial sediment on terraces. These soils are mostly along major upland drainageways. They are friable, calcareous silt loam throughout. Roxbury soils are well drained and have moderate permeability.

The McCook soils are nearly level to gently undulating. They are mostly on the low terraces and flood plains of the North and South Forks of the Solomon River. McCook soils have a surface layer of coarse silt loam about 12 inches thick. The layer below that is friable, calcareous coarse silt loam about 18 inches thick. The substratum is coarse silt loam that is stratified with silty clay loam, loam, and very fine sandy loam. McCook soils are well drained and have moderate permeability.

The minor soils in this association are the Detroit, Inavale, Munjor, and New Cambria soils; Alluvial

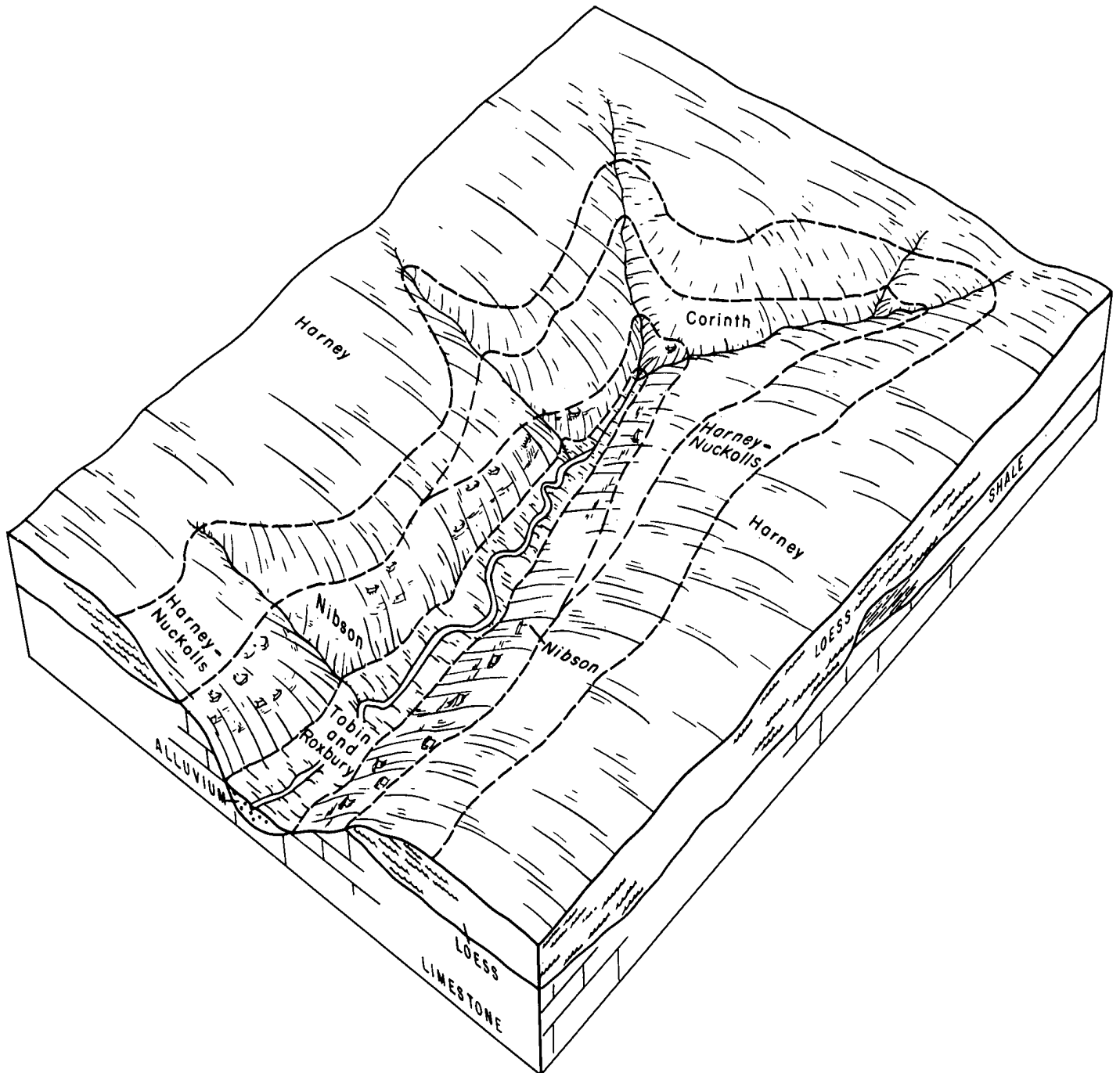


Figure 6.—Representative pattern of the soils in the Harney-Corinth-Nibson association in the southeastern part of the county.

land, loamy; and Alluvial land, mixed. The Detroit and New Cambria soils are moderately fine textured and are in slightly concave places on terraces. The Inavale and Munjor soils are moderately coarse textured or coarse textured and are on undulating to hummocky low terraces and flood plains of the North and South Forks of the Solomon River. Alluvial land, loamy, and Alluvial land, mixed, are on the flood plain and in channeled areas of the North and South Forks of the Solomon River and smaller streams.

The soils of this association are intensively cultivated. Large areas in the valleys of the North and South Forks of the Solomon River are irrigated. The major crops are wheat, grain sorghum, corn, and al-

falfa. The Inavale soils, Alluvial land, loamy, and Alluvial land, mixed, are suitable for grazing, wildlife habitat, and recreation uses. The main concerns in managing the cultivated areas are conserving moisture and maintaining soil tilth and fertility. In areas used for grazing, practices are needed that help maintain a vigorous stand of grass.

##### 5. Harney-Corinth-Nibson association

*Deep to shallow, nearly level to moderately steep, loamy and clayey soils formed in loess and material weathered from shale and limestone; on uplands.*

This association is in broad areas of the uplands that

are nearly level to gently sloping and dissected by sloping and moderately steep sided, intermittent drainageways. The association consists of a mantle of loess over shale, interbedded limestone, and limy shale (fig. 6).

This association covers about 11 percent of the county. Harney soils make up about 60 percent of the association; Corinth soils, 15 percent; Nibson soils, 5 percent; and minor soils, 20 percent.

The Harney soils are nearly level to sloping and are in broad areas between drainageways. These soils are deep and have a surface layer of silt loam about 10 inches thick. The subsoil is friable silty clay loam about 20 inches thick. The substratum is silt loam. Harney soils are well drained and have moderately slow permeability.

The Corinth soils are sloping to strongly sloping and are downslope from the Harney soils. Corinth soils are moderately deep and calcareous and have a surface layer of silty clay loam about 7 inches thick. The subsoil is firm silty clay about 10 inches thick. The substratum is silty clay. Below this layer, at a depth of about 26 inches, is unweathered shale. Corinth soils are well drained and have moderately slow permeability.

The Nibson soils are strongly sloping to moderately steep and are on narrow ridgetops and side slopes. These soils are shallow and have a surface layer of calcareous silt loam about 8 inches thick. The subsoil is silty clay loam about 6 inches thick. The substratum is silty clay that contains many fragments of limestone and shale. Below this layer, at a depth of about 19 inches, is soft limestone and shale. In many places limestone crops out. Nibson soils are somewhat excessively drained and have moderate permeability above the limestone and shale.

The minor soils in this association are the Armo, Nuckolls, Roxbury, and Tobin soils. Armo soils are mostly on foot slopes next to Nibson soils. Nuckolls soils are near Harney soils in sloping areas. Tobin and Roxbury soils are on the flood plains of upland drainageways.

Most of this association is cultivated. The soils are suited to all the crops commonly grown in the county. The steeper Corinth and Nibson soils are used mostly for range. The main concerns in managing the cultivated areas are controlling erosion, conserving moisture, and maintaining soil tilth and fertility. Proper range management and development of water resources are the main concerns in uncultivated areas.

## Descriptions of the Soils

This section describes the soil series and mapping units in Osborne County. Each soil series is described in detail, and then each mapping unit in that series is described. Unless stated otherwise, information given for the soil series also applies to the mapping units in that series. Thus, for complete information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Extent
Alluvial land, loamy -----	6,100	1.1
Alluvial land, mixed -----	1,550	.3
Armo silt loam, 3 to 7 percent slopes -----	5,800	1.0
Armo silt loam, 3 to 7 percent slopes, eroded -----	1,100	.2
Armo-Bogue complex -----	59,000	10.3
Bogue clay, 3 to 15 percent slopes -----	7,800	1.4
Brownell-Wakeen complex -----	22,500	3.9
Corinth silty clay loam, 3 to 7 percent slopes -----	4,350	.8
Corinth silty clay loam, 7 to 15 percent slopes -----	5,100	.9
Detroit silty clay loam -----	6,000	1.0
Harney silt loam, 0 to 1 percent slopes -----	6,900	1.2
Harney silt loam, 1 to 3 percent slopes -----	84,000	14.6
Harney silt loam, 3 to 7 percent slopes -----	43,000	7.5
Harney silty clay loam, 2 to 7 percent slopes, eroded -----	5,700	1.0
Harney-Mento complex, 1 to 3 percent slopes -----	14,200	2.5
Harney-Mento complex, 3 to 7 percent slopes -----	32,500	5.7
Harney-Nuckolls complex, 3 to 8 percent slopes -----	79,000	13.7
Heizer-Brownell complex -----	55,000	9.6
Hord silt loam -----	26,000	4.5
Inavale loamy fine sand -----	1,950	.3
McCook silt loam -----	7,300	1.3
Munjoy-McCook complex -----	6,900	1.2
New Cambria silty clay -----	3,850	.7
New Cambria silty clay, frequently flooded -----	1,800	.3
Nibson complex -----	3,350	.6
Roxbury silt loam -----	22,000	3.8
Roxbury silt loam, channeled -----	730	.1
Roxbury complex -----	5,400	.9
Timken-Bogue clays -----	10,200	1.7
Timken-Shale outcrop complex -----	350	.1
Tobin and Roxbury silt loams -----	24,250	4.2
Wakeen-Mento complex, 3 to 8 percent slopes -----	19,700	3.4
Borrow pits -----	620	.1
Solomon River -----	720	.1
<b>Total -----</b>	<b>574,720</b>	<b>100.0</b>

material. For each series, two descriptions of this profile are given. The first is brief and in familiar terms. The second is detailed and in technical terms. It is useful mainly to scientists, engineers, and others who need to make thorough and precise studies of soils. Unless stated otherwise, the colors given in the descriptions are those of a dry soil.

As mentioned in the section "How This Survey Was Made," not all mapping units are in a soil series. Alluvial land, loamy, and Alluvial land, mixed, for example, do not belong to a soil series; nevertheless, they are listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, range site, and windbreak suitability group in which the mapping unit has been placed. An explanation of the capability classification system is given in the section "Capability Grouping," and a discussion of windbreak suitability groups is given in the section "Management of Soils for Windbreaks." The "Guide to Mapping Units" at the back of this survey shows the capability unit, range site, and windbreak suitability group for each soil in the survey area.

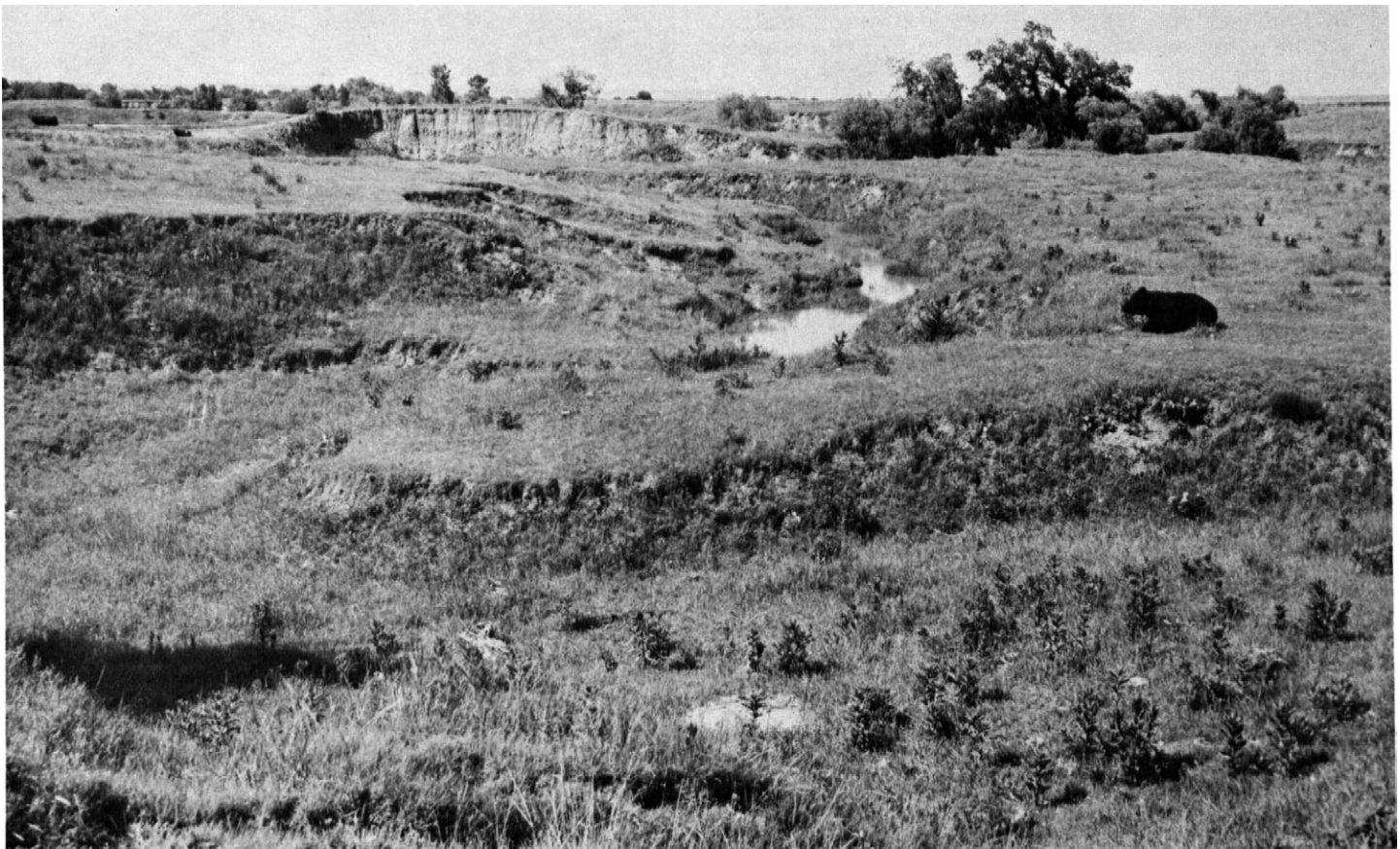


Figure 7.—Representative area of Alluvial land, loamy.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils are defined in the Glossary at the end of this survey, and more detailed information about terminology and the methods of soil mapping can be obtained from the Soil Survey Manual (7).<sup>1</sup>

Small areas of highly contrasting soils or of soils that have special features, such as rock outcrops, affect the use of soils. These areas are shown on the detailed soil map by spot symbols. The symbols are listed on the legend sheet under "Soil Survey Data," but not all of the symbols listed are used on the map of Osborne County. The spot symbols that have been used are discussed in the following paragraphs.

A spot symbol is used to identify rock outcrops and gravel pockets in areas of moderately deep and deep soils that generally do not have outcrops of bedrock or gravel pockets. Each symbol represents an area about 1 to 3 acres in size.

A spot symbol is used to identify a severely eroded area. Each symbol represents an area about one-half acre to 2 acres in size. Crop growth generally is poor in these areas because the fertility is low and tilth is poor. If clayey material has been exposed by erosion, it is difficult to prepare a seedbed. If material that is

high in lime has been exposed, iron chlorosis can affect grain sorghum.

### Alluvial Land

Alluvial land is a miscellaneous land type that is mapped in Osborne County as Alluvial land, loamy, and Alluvial land, mixed. Areas of this land type range from 200 feet to somewhat more than 900 feet in width. Stream channels 20 to 70 feet wide and 3 to 10 feet deep make up about 15 percent of the acreage. These areas are subject to frequent flooding.

**Aa—Alluvial land, loamy.** This land type consists of dark, loamy alluvial sediment. It is deep and nearly level to steep and broken, and it occurs along deep, narrow channels on flood plains of local intermittent streams (fig. 7). The slope is 0 to 30 percent.

In most places the surface layer is dark, calcareous silt loam, but in some places it is silty clay loam. The subsoil and substratum are made up of alternating layers of silt loam, loam, and silty clay loam. In some places layers having a high content of limestone gravel are below the surface layer. Except during long rainy periods, the soil material is excessively drained. Run-off is medium.

Alluvial land, loamy, is suitable only for use as range and wildlife areas and for windbreaks. Cultivation is difficult or impossible because of the numerous chan-

<sup>1</sup>Italic numbers in parentheses refer to Literature Cited, p. 59.

nels and frequent flooding. This land type is used almost entirely for range that has a cover consisting of native grasses, trees, woody shrubs, and annual weeds.

Deferred grazing or rotation deferred grazing and proper stocking rates can help maintain or improve the vigor and composition of the grasses. Weeds can be controlled by mechanical methods or by chemicals. Watershed improvement helps control flooding. (Capability unit VIw-2, Loamy Lowland range site, wind-break suitability group 1)

**Ab—Alluvial land, mixed.** This land type is made up of alluvial sediment of recent origin. It is nearly level to undulating and occurs in strips along the channels of the North and South Forks of the Solomon River. The slope is 0 to 4 percent. It is only slightly above the riverbed and is flooded when the rivers overflow. Sediment is deposited or removed in layers that range from a fraction of an inch to a foot or more in thickness.

In most places the surface layer is calcareous grayish-brown loam intermingled with silty clay loam or silty clay. Below the surface layer the soil material is of similar texture but is stratified. In some places the surface layer is calcareous loamy sand; it overlies a layer of thinly stratified silty clay loam and silt loam; the material below that is loamy sand or sand. In other places the surface layer is silt loam or silty clay; it overlies a layer of loamy sand; the underlying material is silty clay loam.

In some places small areas of McCook, Inavale, and Munjor soils were included with this land type in mapping.

This land type is not well suited to cultivation because overflows are frequently damaging. It is almost entirely used for range and is suitable also for use as wildlife areas and for windbreaks for sheltering livestock in winter. The cover consists of trees, woody shrubs, native grasses, and annual weeds.

Deferred grazing or rotation deferred grazing and proper stocking rates can help maintain or improve the vigor and composition of the grasses and forbs. (Capability unit IVw-1, Loamy Lowland range site, wind-break suitability group 1)

## Armo Series

The Armo series consists of deep, well-drained soils on uplands. These soils formed in colluvial material that came from limestone hills capped with loess. They are sloping to moderately steep and are mainly on foot slopes in the hilly limestone areas throughout the county.

In a representative profile the surface layer is dark grayish-brown silt loam about 11 inches thick. The subsoil is about 17 inches thick. It is grayish-brown, friable light silty clay loam in the upper 6 inches and pale brown, friable light silty clay loam in the lower 11 inches. The substratum is very pale brown heavy silt loam. All horizons are calcareous and contain many chips and pebbles of limestone (fig. 8).

Armo soils have a high available water capacity and moderate permeability. They are subject to water erosion.

Representative profile of Armo silt loam, in an area



Figure 8.—Representative profile of Armo silt loam.

of Armo-Bogue complex, about 1,000 feet south and 200 feet east of the northwest corner of sec. 6, T. 9 S., R. 11 W., in native grass:

- A1—0 to 11 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium and fine, granular structure; slightly hard, friable; many fine and medium roots; many chips and pebbles of limestone; many worm casts; slight effervescence; mildly alkaline; gradual, smooth boundary.
- B1—11 to 17 inches, grayish-brown (10YR 5/2) light silty clay loam, brown (10YR 5/3) moist; moderate, medium, granular structure; hard, friable; many fine and medium roots; numerous worm casts, some mixing of colors from horizons above and below by worm action; many chips and pebbles of limestone; strong effervescence; mildly alkaline; gradual, smooth boundary.
- B2—17 to 28 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) moist; moderate, medium, subangular blocky structure parting to moderate, fine, granular; hard, friable; many fine and medium roots; many worm casts; many chips and pebbles of limestone; few films and threads of lime at a depth of 27 to 29 inches; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C—28 to 60 inches, very pale brown (10YR 7/3) heavy silt loam, brown (10YR 5/3) moist; massive; slightly hard, friable; few fine roots; thin strata of chips and pebbles of limestone; violent effervescence; moderately alkaline.

The A horizon generally is silt loam or loam but in some places is light silty clay loam. It is 10 to 20 inches thick. The B horizon generally is silty clay loam, but in places it is loam or clay loam. Chips and pebbles of limestone are





*Figure 9.—Typical area of Armo-Bogue complex.*

scattered throughout all horizons. In some places there are thin strata that contain many chips and pebbles of limestone in the lower part of the B horizon and in the C horizon.

Armo soils are near Brownell, Heizer, Nibson, Timken, and Wakeen soils. They lack the underlying chalk or limestone that those soils have. They are deeper and less clayey than Timken soils.

**Ar—Armo silt loam, 3 to 7 percent slopes.** This soil is mainly on convex foot slopes adjacent to limestone hills. The surface layer is about 14 inches thick. In most places this soil has fewer fragments of limestone in the surface layer and subsoil than the soil described as representative for the series.

Included with this soil in mapping were a few small areas of Harney silt loam and the Roxbury complex. Also included were outcropping pockets of limestone pebbles.

This Armo soil is suited to most crops and grasses commonly grown in the county. Sorghum is likely to be affected by chlorosis because the soil contains a large amount of lime. Water erosion is a serious hazard if cultivated crops are grown. The main concerns of management are control of water erosion and conservation of moisture. (Capability unit IIIe-3, Limy Upland range site, windbreak suitability group 3)

**As—Armo silt loam, 3 to 7 percent slopes, eroded.** This soil is mainly on convex foot slopes adjacent to limestone hills. It has lost nearly all of its original surface layer through erosion. The present surface layer is silt loam, but a few areas of silty clay loam and gravelly silt loam were included in mapping. The

present surface layer ranges from dark grayish brown to brown, and in some places it is a few inches thinner than is within the range defined for the series. A few gullies have been formed, and in some places pebbles of limestone are on the surface.

Also included with this soil in mapping were outcropping pockets of limestone gravel.

This Armo soil is poorly suited to cultivation because it is subject to erosion. Conservation practices, such as terracing, are difficult to apply. Other concerns of management are maintaining soil structure and fertility. All the acreage has been cultivated, but about 50 percent has been reseeded to native grass or has been abandoned. Reseeding to suitable native grasses is needed in areas that are not cultivated and in those that have been abandoned. (Capability unit IVE-3, Limy Upland range site, windbreak suitability group 3)

**Ax—Armo-Bogue complex.** This complex is on broken to moderately steep side slopes and short sloping ridges (fig. 9). In most places it is on dissected foot slopes immediately below limestone ridgetops. Some small areas are isolated from the limestone ridgetops. The slope is 7 to 20 percent.

About 60 percent of the complex is Armo silt loam, 20 percent is Bogue clay, and 20 percent is Roxbury silt loam, Harney silt loam, and Timken clay. Armo, Bogue, and Timken soils are intermingled on the steeper side slopes. The Roxbury soil is in narrow drainage ways, and the Harney soil is on loess-capped ridges.

The Armo soil has the profile described as representative of the Armo series. The Bogue soil has a profile similar to the one described as representative of its series.

Included with this complex in mapping were small areas of Heizer and Brownell soils.

Nearly all of the acreage is used for range. If properly managed, the soils support good stands of native grass. Proper stocking and deferred grazing can help maintain or improve the native range. A few small areas are cultivated and are moderately to severely eroded. Further erosion can be prevented by seeding the cultivated areas to native grass. The Armo soil supports scattered trees and shrubs that provide food and cover for wildlife. (Both soils, capability unit VIe-1; Armo soil, Limy Upland range site, windbreak suitability group 3; Bogue soil, Blue Shale range site, windbreak suitability group 4)

### Bogue Series

The Bogue series consists of moderately deep, sloping to steep, moderately well drained soils. These soils are on uplands below limestone hills throughout the county. They formed in material that weathered from neutral to acid shale.

In a representative profile the surface layer is slightly acid, gray clay about 8 inches thick. The subsoil is very firm, gray clay about 12 inches thick. The substratum is gray clay, and it has many, small, unweathered fragments of shale. Clay shale is at a depth of about 33 inches. This profile is noncalcareous throughout.

Bogue soils have a low available water capacity and very slow permeability. Surface runoff is rapid.

Representative profile of Bogue clay, 3 to 15 percent slopes, about 1,400 feet north and 150 feet east of the southwest corner of sec. 2, T. 10 S., R. 11 W., in range:

- A1—0 to 8 inches, gray (2.5Y 5/1) clay, very dark gray (5Y 3/1) moist; weak, medium and fine, subangular blocky structure; extremely hard, firm; many fine and medium roots; few worm casts; neutral; gradual, smooth boundary.
- B2—8 to 20 inches, gray (2.5Y 5/1) clay, dark gray (2.5Y 4/1) moist; moderate, medium and fine, blocky structure; extremely hard, very firm; many fine roots; common slickenside faces; scattered fragments of calcite; neutral; gradual, smooth boundary.
- C1—20 to 26 inches, gray (2.5Y 5/1) clay, scattered flecks of yellowish brown (10YR 5/4), dark gray (2.5Y 4/1) moist; moderate, medium, subangular blocky structure; extremely hard, very firm; common fine roots; scattered, very small, disoriented fragments of unweathered shale; scattered patches of gypsum; few black concretions; neutral; gradual, smooth boundary.
- C2—26 to 33 inches, gray (2.5Y 6/1) mixed with grayish-brown (2.5Y 5/2) weathered clay shale, olive gray (5Y 4/2) moist; moderate, medium, platy structure; extremely hard, very firm; few fine roots follow bedding planes; many fine fragments of shale; common films and threads of gypsum; medium acid; clear, smooth boundary.
- R—33 to 47 inches +, gray (5Y 6/1) and thin strata of light olive-brown (2.5Y 5/4) clay shale, dark gray (5Y 5/1) and thin strata of olive brown (2.5Y 4/4) moist; thin platy structure; gypsum crystals fill horizontal cavities; medium acid.

The A1 horizon ranges from 5 to 10 inches in thickness.

It is generally mildly alkaline to neutral, but in some places it is moderately alkaline. In some places the A horizon is silty clay. The B2 horizon ranges from 8 to 12 inches in thickness. Depth to unweathered shale is 20 to 40 inches. The parent shale is medium acid to very strongly acid.

Bogue soils are near Corinth and Timken soils. They are more gray, have less lime throughout, and have more clay than Corinth soils. They are deeper over unweathered shale than Timken soils.

**Bo—Bogue clay, 3 to 15 percent slopes.** This soil is on ridges and slopes of erosional uplands. Individual areas are 10 to 300 acres in size. This soil has the profile described as representative of the Bogue series, but in cultivated areas the surface layer is commonly 6 inches thinner.

Included with this soil in mapping were a few small areas of Timken soils. Also included were small areas of New Cambria soils along narrow drainageways.

Natural fertility is low, and the organic matter content is low. Roots can penetrate to a depth of 20 to 40 inches. This soil is droughty during periods of low rainfall. Nearly all of the acreage is used for range, but a few small areas are cultivated. Erosion is only a slight hazard on rangeland but a severe hazard in cultivated areas. A large amount of forage is produced where good range management is practiced. (Capability unit VIe-1, Blue Shale range site, windbreak suitability group 4)

### Brownell Series

The Brownell series consists of moderately deep, strongly sloping to steep, well-drained, loamy soils on uplands. These soils formed in material that weathered from thick, massive limestone.

In a representative profile the surface layer is grayish-brown, strongly calcareous loam about 8 inches thick. The subsoil is light brownish-gray, friable gravelly loam about 7 inches thick. It contains many fragments of limestone. The substratum is white channery loam, about 12 inches thick, and it contains many fragments of limestone and rocks. White, dense, chalky limestone bedrock is at a depth of about 27 inches (fig. 10).

Brownell soils have moderate permeability and a low available water capacity. Surface runoff is medium to rapid. The root zone is moderately shallow, but the soils are productive if used for range.

The Brownell soils in Osborne County are mapped only in complexes with Heizer and Wakeen soils.

Representative profile of Brownell loam, in an area of Brownell-Wakeen complex, about 500 feet south and 200 feet west of the northeast corner of sec. 28, T. 6 S., R. 15 W., in native grass:

- A1—0 to 8 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; moderate, medium and fine, granular structure; slightly hard, friable; many fine and medium roots; many worm casts; fragments of limestone and pebbles are less than 7 percent of soil mass, occasional fragments of limestone up to 3 inches or more in size; violent effervescence; moderately alkaline; clear, smooth boundary.
- B2—8 to 15 inches, light brownish-gray (10YR 6/2) gravelly loam, dark grayish brown (10YR 4/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine and medium roots; common worm casts; many fragments of limestone up to 3 inches in size, a few are more than 3 inches



Figure 10.—Representative profile of Brownell gravelly loam that shows the many fragments of limestone that are typical of the Brownell soils.

and increase in size with depth; secondary carbonate pendants on lower sides of larger fragments of limestone; violent effervescence; moderately alkaline; clear, smooth boundary.

C—15 to 27 inches, white (10YR 8/2) channery loam, pale brown (10YR 6/3) moist; moderate, very fine, granular structure; slightly hard, friable; few fine roots; common worm casts; many fragments of limestone and rocks; most fragments have thin deposits of secondary carbonate pendants on lower side; violent effervescence; moderately alkaline; abrupt boundary.

R—27 to 30 inches, white, dense, chalky limestone bedrock; unaltered (Fort Hays chalky limestone is member of the Niobrara formation).

In some places the A horizon is gravelly loam. Loose limestone is common on the surface and scattered through the A horizon. Depth to underlying dense limestone ranges from 20 to 40 inches.

Brownell soils are near Armo, Mento, Heizer, and Wakeen soils. They have more fragments of limestone in all horizons than Armo and Wakeen soils. Brownell soils are thicker over chalky limestone than Heizer soils. They have less clay throughout and are less deep to limestone than Mento soils.

**Bw—Brownell-Wakeen complex.** This complex is on low ridges and side slopes of upland drainageways. Most large areas are along drainageways. Many small areas are on scattered low ridges and small hills. The slope is 8 to 20 percent.

About 50 percent of the complex is Brownell loam, 20 percent is Wakeen silt loam, and 15 percent is outcrops of barren to semibarren chalky limestone. The remaining 15 percent is Armo silt loam and Roxbury silt loam. The Armo soil is on colluvial foot slopes, and the Roxbury soil is in narrow drainageways.

The Brownell soil and the Wakeen soil each has the profile described as representative of its series.

Included with this complex in mapping were small areas of Mento soils and Harney soils. These soils, for the most part, have a slope of less than 8 percent and are mainly on the fringes of the mapped areas of this complex.

Nearly all of the acreage is used for range (fig. 11).



Figure 11.—Native range on Brownell-Wakeen complex, 8 to 20 percent slopes.

If properly managed, the soils support good stands of native grass. Proper stocking and deferred grazing can help maintain or improve native range. A few small areas are cultivated and are moderately to severely eroded. Further erosion can be controlled by seeding the cultivated areas to native grass. The Armo and Roxbury soils support scattered shrubs that provide food and cover for wildlife. (Capability unit VIe-2, Limy Upland range site, windbreak suitability group 4)

## Corinth Series

The Corinth series consists of sloping to strongly sloping, well-drained soils that are moderately deep over shale. These soils formed in material that weathered from calcareous, clayey shale.

In a representative profile the surface layer is grayish-brown silty clay loam about 7 inches thick. The subsoil is pale-brown, firm silty clay about 10 inches thick. The substratum is light yellowish-brown silty clay and contains many small fragments of shale. Unweathered, very pale brown silty clay shale is at a depth of about 26 inches. These soils are calcareous throughout.

Corinth soils have a low available water capacity and moderately slow permeability.

Representative profile of Corinth silty clay loam, 7 to 15 percent slopes, about 500 feet south and 200 feet west of the northeast corner of sec. 16, T. 10 S., R. 11 W., in native range:

A1—0 to 7 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; strong, medium and fine, granular structure; hard, friable; many medium and fine roots; many worm casts; strong effervescence; mildly alkaline; gradual, smooth boundary.

B2—7 to 17 inches, pale-brown (10YR 6/3) silty clay; brown (10YR 5/3) moist; moderate, fine, subangular blocky structure; very hard, firm; common fine roots; few worm casts; strong effervescence; moderately alkaline; gradual, smooth boundary.

C—17 to 26 inches, light yellowish-brown (10YR 6/4) silty clay, yellowish brown (10YR 5/5) moist; moderate, medium, subangular blocky structure; very hard, firm; few fine roots; few scattered fragments of



**Figure 12.**—An area of Corinth silty clay loam, 3 to 7 percent slopes, that has been seeded to native grass.

shale and fossil oyster shells; violent effervescence; moderately alkaline; gradual, smooth boundary.

C2—26 to 48 inches, very pale brown (10YR 7/4) silty clay shale, yellowish brown (10YR 5/6) moist; medium to thick platy structure, some vertical cracks in upper 10 inches; strong effervescence; moderately alkaline; few fine roots penetrate upper 6 inches and follow vertical cracks and bedding planes.

The solum is 15 to 25 inches thick. Unweathered shale is at a depth of 20 to 40 inches. In some places where these soils have been disturbed by plowing, the Ap horizon is yellowish-brown or light yellowish-brown heavy silty clay loam or light silty clay. The B horizon is silty clay loam to silty clay 7 to 15 inches thick. Fragments of shale, aragonite, or fossil oyster shells are in the lower part of the B horizon in some places.

Corinth soils are near Bogue, Nibson, and Timken soils. They are browner and have more lime throughout their profile than Bogue or Timken soils. They are more clayey than Nibson soils.

**Co—Corinth silty clay loam, 3 to 7 percent slopes.** This soil is on side slopes adjacent to upland drainageways (fig. 12). In most places it is slightly deeper than the soil described as representative of the Corinth series. Also, the soil is eroded in places, and tillage has mixed part of the subsoil with the remaining surface layer. These places are shown on the detailed soil map by the symbol for a severely eroded spot.

Included with this soil in mapping were a few small areas of Bogue, Roxbury, and New Cambria soils.

This soil is not well suited to cultivation. It has moderate natural fertility and a low organic-matter content, and its root zone extends to a depth of 20 to 40 inches. Nearly all the acreage is in wheat and sorghum.

Wheat is a suitable crop, but sorghum is sometimes affected by chlorosis, a yellowing of the leaves, because the content of lime is high in this soil. Water erosion is the main hazard, but soil blowing also is a hazard where the soil is not protected. Conserving water and maintaining good soil structure and fertility are also concerns of management. (Capability unit IVE-4, Limy Upland range site, windbreak suitability group 3)

**Cr—Corinth silty clay loam, 7 to 15 percent slopes.** This soil is on ridges and side slopes of drainageways. It has the profile described as representative for the Corinth series.

Included with this soil in mapping were a few small areas of Bogue and Nibson soils.

Natural fertility is moderate, and the organic-matter content is low. The effective root zone extends to a depth of 20 to 40 inches. Water erosion is the main hazard. Nearly all the acreage is used for range, but a few small areas have been cultivated. In cultivated areas erosion is very severe, but areas used for range are only slightly eroded. A large amount of forage is produced if good range management is practiced. (Capability unit VIe-3, Limy Upland range site, windbreak suitability group 3)

### **Detroit Series**

The Detroit series consists of deep, nearly level, well drained and moderately well drained soils. These soils are on high terraces of the North and South Forks of the Solomon River and larger local creeks. They formed in silty alluvial deposits.



In a representative profile the surface layer is very dark grayish-brown silty clay loam about 12 inches thick. The subsoil has a combined thickness of about 34 inches. The upper part of the subsoil is very dark grayish-brown, firm, light silty clay. The lower part is dark grayish-brown to brown, calcareous, firm, light silty clay that becomes friable silty clay loam with increasing depth. The substratum is pale-brown, calcareous, light silty clay loam.

Detroit soils have slow permeability and a high available water capacity. Runoff is slow, and the hazard of erosion is only slight. These soils are productive and have high natural fertility.

Representative profile of Detroit silty clay loam, about 2,000 feet north and 150 feet west of the southeast corner of sec. 21, T. 7 S., R. 13 W., in a cultivated area:

- A1—0 to 12 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) moist; moderate, fine, granular structure; hard, friable; many fine roots; few worm casts; slightly acid; gradual, smooth boundary.
- B21t—12 to 25 inches, very dark grayish-brown (10YR 3/2) light silty clay, very dark brown (10YR 2/2) moist; moderate, fine, angular blocky structure; very hard; firm; many fine roots; scattered worm casts; thin clay films on ped faces; neutral; gradual, smooth boundary.
- B22t—25 to 38 inches, dark grayish-brown (10YR 4/2) light silty clay, very dark grayish brown (10YR 3/2) moist; moderate, medium and fine, angular blocky structure; very hard, firm; few roots; some mixing of colors from horizon above because of vertical cracks; scattered clay films on some ped faces; slight effervescence; mildly alkaline; gradual, smooth boundary.
- B3ca—38 to 46 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; moderate, medium, subangular blocky structure; hard, friable; many fine pores; scattered worm casts; many films and threads of lime; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C—46 to 50 inches, pale-brown (10YR 6/3) light silty clay loam, dark brown (10YR 4/3) moist; weak, medium, subangular blocky structure; slightly hard, friable; common films, threads, and small accumulations of segregated lime; strong effervescence; moderately alkaline; porous.

The A1 horizon is silty clay loam to heavy silt loam 8 to 14 inches thick. In places the B2 horizon is heavy silty clay loam. Depth to segregated lime ranges from 22 to 40 inches. The C horizon is silt loam in places.

Detroit soils are near Hord, New Cambria, and Roxbury soils. Detroit soils are more clayey than Hord soils. Their solum has less clay than that of the New Cambria soils. Detroit soils are more clayey and are leached of lime to a greater depth than Roxbury soils.

**De—Detroit silty clay loam.** This soil is mainly on the high terraces of the North and South Forks of the Solomon River and larger creeks in the county. The slope is 0 to 2 percent.

Included with this soil in mapping were a few small areas of Hord and New Cambria soils.

This Detroit soil is well suited to all crops commonly grown in the county. Nearly all of the acreage is in wheat, grain sorghum, or alfalfa. The soil can be irrigated if water of suitable quality is available. The concerns of management on this soil are slight. Practices to control erosion and conserve water can easily be applied. (Capability unit I-3, Loamy Terrace range site, windbreak suitability group 1)

## Harney Series

The Harney series consists of deep, nearly level to sloping, well-drained soils on the uplands. These soils formed in alkaline or calcareous loess.

In a representative profile the surface layer is dark grayish-brown silt loam about 10 inches thick. The subsoil is about 20 inches thick. It is dark grayish-brown, friable light silty clay loam in the upper part; grayish-brown, firm silty clay loam in the middle part; and pale-brown, friable light silty clay loam in the lower part. The substratum is silt loam that is pale brown to a depth of about 46 inches and is light gray below that (fig. 13).

Runoff is medium on the Harney soils, and they are subject to water erosion. Permeability is moderately slow, and the available water capacity is high. The natural fertility is high.

Representative profile of Harney silt loam, 1 to 3 percent slopes, about 2,000 feet west and 350 feet north of the southeast corner of sec. 20, T. 7 S., R. 13 W., in a cultivated area:

- A1—0 to 10 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine roots; many worm casts; neutral; clear, smooth boundary.
- B1—10 to 13 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine roots; many worm casts; neutral; clear, smooth boundary.



Figure 13.—Representative profile of Harney silt loam that shows the dark surface layer and subsoil.

- B21t—13 to 18 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; moderate, medium and fine, blocky structure; hard, firm; many fine roots; many roots follow ped faces; thin patchy clay films; mildly alkaline; gradual, smooth boundary.
- B22t—18 to 26 inches, grayish-brown (10YR 5/2) silty clay loam, dark brown (10YR 4/3) moist; moderate, medium, subangular blocky structure; hard, firm; many fine roots; mildly alkaline; gradual, smooth boundary.
- B3—26 to 30 inches, pale-brown (10YR 6/3) light silty clay loam, dark brown (10YR 4/3) moist; moderate, medium, subangular blocky structure; slightly hard, friable; few fine roots; common fine pores; scattered worm casts; mildly alkaline; gradual, smooth boundary.
- Cca—30 to 46 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; weak, medium, subangular blocky structure; slightly hard, friable; few fine roots; very porous; many films, threads, and soft accumulations of lime; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C—46 to 72 inches, light-gray (10YR 7/2) silt loam, brown (10YR 5/3) moist; massive; very porous; scattered accumulations of soft lime; strong effervescence; moderately alkaline.

The A horizon is silt loam to light silty clay loam 8 to 13 inches thick. The B horizons range from 17 to 26 inches in combined thickness. The B2 horizon ranges from silty clay loam to silty clay. In most places lime is at a depth between 18 and 33 inches, but it is deeper in some places.

Harney soils are near Mento, Nuckolls, and Tobin soils. Depth to free lime is greater in Harney soils than it is in Mento soils, and the transition from the A to the B horizon is more gradual. Harney soils have a somewhat finer textured subsoil and are less brown than Nuckolls soils. They are more clayey than Tobin soils.

**Ha—Harney silt loam, 0 to 1 percent slopes.** In most places the surface layer of this soil is about 13 inches thick. The subsoil is about 25 inches thick and contains free lime at a depth of about 33 inches.

Included with this soil in mapping were a few small areas of Mento silty clay loam that have a slope of about 1 percent. The Mento soil is mainly in the western half of the county.

Most areas of this Harney soil are cultivated. The soil is well suited to wheat, grain sorghum, and other crops commonly grown in the county. Loss of soil by erosion is minor on this soil, but runoff can reduce the amount of water available to plants, which limits crop growth. Inadequate rainfall is the principal limitation. Reducing runoff and conserving moisture are the main concerns of management. (Capability unit IIC-1, Loamy Upland range site, windbreak suitability group 2)

**Hb—Harney silt loam, 1 to 3 percent slopes.** This soil is extensive and is on broad uplands in areas that are between 50 and 500 acres in size. This soil has the profile described as representative for the series.

Included with this soil in mapping were a few small areas of Mento silty clay loam. These areas are in places where the parent loess is thin and is over chalky shale or soft limestone. Also included were small areas in the western part of the county where the subsoil is heavy silt loam or light silty clay loam. In addition, there are small included areas of Nuckolls soils where the slope generally is more than 3 percent, and a few small areas where erosion has thinned the surface layer. Most of these areas are shown on the detailed soil map by the symbol for a severely eroded spot.

This soil is well suited to all crops commonly grown in the county. It also is well suited to irrigation if water of suitable quality is available. Nearly all the acreage is in wheat or grain sorghum but some of it is in alfalfa or forage sorghum. Water erosion and conservation of water are concerns of management. (Capability unit IIE-1, Loamy Upland range site, windbreak suitability group 2)

**He—Harney silt loam, 3 to 7 percent slopes.** This soil is along drainageways and on rounded hills. In some areas the surface layer has been thinned by erosion. These areas are shown on the detailed soil map by the symbol for a severely eroded spot.

Included with this soil in mapping were a few small areas of Nuckolls soils where the slope generally is more than 6 percent. Small areas of Mento soils in the western part of the county also were included.

This soil is productive and is suited to all crops commonly grown in the county. Most of the acreage is in wheat or grain sorghum. Water erosion is a severe hazard unless the soil is well managed. Conservation of water also is a concern of management. (Capability unit IIIe-1, Loamy Upland range site, windbreak suitability group 2)

**Hd—Harney silty clay loam, 2 to 7 percent slopes, eroded.** This soil is mainly on side slopes along drainageways that are near other Harney soils. The profile of this soil is similar to the one described as representative for the series, but the surface layer is thinner. Erosion has been moderate to severe. Runoff removed most of the original surface layer of silt loam, and the present surface layer is silty clay loam. In most places tillage has mixed some of the subsoil with the remaining part of the original surface layer.

Small areas of Harney silt loam, 1 to 3 percent slopes, were included with this soil in mapping. Also included were small areas of Nuckolls and Mento soils.

This soil is suited to most crops commonly grown in the county. Most of the acreage is in wheat or grain sorghum, but small grain is more suitable than row crops. Natural fertility is moderate to low. The surface layer may seal over during rain, and if it does, runoff is excessive and there is a loss of available water. Consequently, water erosion is a severe hazard unless the soil is well managed. Maintaining good tilth and fertility are other concerns of management. This soil is well suited to grasses commonly grown in the county. (Capability unit IIIe-2, Loamy Upland range site, windbreak suitability group 2)

**He—Harney-Mento complex, 1 to 3 percent slopes.** This complex is on low, convex ridges. About 50 percent of it is Harney silt loam, 40 percent is Mento silty clay loam, and the rest is Brownell loam and Waken silt loam. These soils are in areas so intermingled that mapping them separately was not practical. The Mento soil is in slickspots or gumbo spots.

The Harney soil in this complex has a profile similar to the one described as representative for the series, but in some places it is underlain by soft limestone at a depth of 40 inches or more. The Mento soil has the profile described as representative for the Mento series.

Nearly all of this complex is cultivated. Wheat and sorghum are suited to these soils. Controlling water erosion and soil blowing is a concern of management. Other concerns are maintaining the rate of water ab-



sorption and conserving water. (Capability unit IIe-2, Clay Upland range site, windbreak suitability group 2)

**Hm—Harney-Mento complex, 3 to 7 percent slopes.** This complex is on rounded hills, on ridges, and along drainageways. About 50 percent of it is Harney silt loam, 40 percent is Mento silty clay loam, and the rest is Brownell loam in some places or Wakeen silt loam in others. The Harney and Mento soils are in areas so intermingled that mapping them separately was not practical. The Mento soil is in slickspots or gumbo spots. The Brownell and Wakeen soils are on small hilltops or side slopes of drainageways.

The Harney soil and the Mento soil are similar to the soil described as representative for their series. In some places, however, the Harney soil is underlain by soft limestone at a depth of 40 inches or more. Also, in small spots erosion has removed most of the original surface layer from the Harney soil and all of that layer from the Mento soil. Here, the present surface layer of the Harney soil is silty clay loam, and that of the Mento soil is lighter colored than normal and is calcareous, or high in content of lime. These eroded spots generally are in the more sloping areas of the complex. Most of these are shown on the detailed soil map by the symbol for a severely eroded spot.

Included with this complex in mapping were small outcrops of rock. Most of these are shown on the soil map by the symbol for rock outcrops.

Nearly all of this complex is cultivated. Wheat and sorghum are suited crops. But in eroded spots and in some areas of the Mento soil where the content of lime is high, sorghum is sometimes affected by chlorosis, a yellowing of the leaves. Water erosion is the main hazard, but soil blowing also occurs where the soils are not protected. Other concerns of management are maintaining good tilth and fertility. Unless the Mento soil is properly managed, its surface layer seals over and crusts readily after rain. This results in a low rate of water absorption. (Capability unit IIIe-2, Clay Upland range site, windbreak suitability group 2)

**Hn—Harney-Nuckolls complex, 3 to 8 percent slopes.** This complex is on the side slopes and the enclosed narrow floor of small upland drainageways. It is about 25 percent Harney silty clay loam, 20 percent Harney silt loam, 25 percent Nuckolls silt loam, and 15 percent soils that are similar to the Nuckolls but lack the dark-colored surface layer and are calcareous at or near the surface. The remaining 15 percent is Tobin silt loam and Roxbury silt loam.

The Harney soils are on the outer fringes of the complex. The Nuckolls soil is downslope from the Harney soils. Tobin and Roxbury soils are on the enclosed valley floor.

Both Harney soils are similar to the soil described as representative for the series, but Harney silty clay loam has a thinner and browner surface layer and is more reddish in the subsoil. The Nuckolls soil has the profile described as representative for the Nuckolls series.

Included with this complex in mapping were a few small areas of Armo and Corinth soils, downslope from the Harney and Nuckolls soils. Also included were small eroded areas that are cut by gullies and many

shallow rills. These areas are shown on the detailed soil map by the symbol for a severely eroded spot.

Most of this complex is cultivated along with the surrounding soils. Nearly all the cultivated areas are in wheat and sorghum. Wheat is more suitable than row crops such as grain sorghum. Controlling water erosion and conserving water are the main concerns of management, but soil blowing is a hazard where the soils are not protected. Other concerns are maintaining good tilth and fertility. If cultivated, the surface layer seals over and crusts readily after rain, and this results in a low rate of water absorption. Because the soils are subject to erosion, they are not well suited to cultivated crops grown year after year. In most places conservation practices are difficult to apply and maintain. (Capability unit IVe-1, Loamy Upland range site, windbreak suitability group 2)

### Heizer Series

This series consists of shallow, strongly sloping to steep, somewhat excessively drained, loamy soils on uplands. These soils formed in material that weathered from thick, massive limestone.

In a representative profile the surface layer is dark-gray gravelly loam about 9 inches thick. The next layer, about 7 inches thick, is light-gray, friable channery loam that has many fragments of limestone. Hard, white, chalky limestone that has scattered vertical cracks is below this. The Heizer soils are strongly calcareous (fig. 14).



Figure 14.—Representative profile of Heizer gravelly loam that shows the underlying limestone.

Surface runoff is medium to rapid on the Heizer soils. Permeability is moderate, and the available water capacity is low to very low. These soils are highly productive if used for range. They have high natural fertility and a shallow effective root zone.

The Heizer soils in Osborne County are mapped only in a complex with Brownell soils.

Representative profile of Heizer gravelly loam, in an area of Heizer-Brownell complex, about 1,000 feet east and 50 feet south of the northwest corner of sec. 1, T. 9 S., R. 13 W., in native grass:

A1—0 to 9 inches, dark-gray (10YR 4/1) gravelly loam, very dark grayish brown (10YR 3/2) moist; moderate, medium and fine, granular structure; slightly hard, friable; many fine roots; many fine and coarse fragments of limestone, few are more than 3 inches in length; strong effervescence; moderately alkaline; gradual, wavy boundary.

C—9 to 16 inches, light-gray (10YR 7/2) channery loam, grayish brown (10YR 5/2) moist; weak, fine, granular structure; slightly hard, friable; many fine roots; many fragments of limestone 3 to 6 inches in length; numerous chips and pebbles of limestone; strong effervescence; moderately alkaline; abrupt, smooth boundary.

R—16 to 24 inches +, white (10YR 8/2) chalky limestone that has scattered vertical cracks.

The A horizon is gravelly loam to loam. The darkened surface layer is less than 10 inches thick. The content of lime in the AC and C horizons exceeds 40 percent. Depth to underlying chalky limestone is 10 to 20 inches.

Heizer soils are near Armo, Brownell, Mento, Timken, and Wakeen soils. In contrast to Heizer soils, Armo soils do not have chalky limestone within the solum; Brownell, Mento, and Wakeen soils are deeper over limestone; and

Timken soils are underlain by noncalcareous shales. Heizer soils contain more coarse fragments than Armo, Mento, Timken, or Wakeen soils.

**Hx—Heizer-Brownell complex.** This complex is on limestone hills and ridges throughout the county. The slope is 7 to 30 percent. About 45 percent of the complex is Heizer gravelly loam, 25 percent is Brownell gravelly loam, 20 percent is Armo silt loam, and the rest is Roxbury silt loam and Timken clay. The Armo soil is downslope from the Heizer and Brownell soils. The Roxbury soil is in narrow drainageways, and the Timken soil is downslope from the Heizer soil (fig. 15).

The Heizer soil in this complex has the profile described as representative for the Heizer series. The Armo soil has a profile similar to the one described as representative for that series, but in some places the underlying material is clayey shale.

Included with this complex in mapping were a few small areas of Harney and Mento soils. These occur where there are caps of loess. Also included were small areas of steep, barren, broken outcrops of limestone.

The soils in this complex are suited to grass. Careful management of grazing is needed to maintain good yields of forage. Proper stocking and deferred grazing help maintain or improve native range. The deeper Armo and Roxbury soils support scattered trees and shrubs that provide good habitat for wildlife. (Both soils, capability unit VII<sub>s</sub>-1, windbreak suitability group 4; Heizer soil, Shallow Limy range site; Brownell soil, Limy Upland range site)



Figure 15.—Typical area of Heizer-Brownell complex.

## Hord Series

The Hord series consists of deep, nearly level, well-drained, loamy soils on the terraces of the North and South Forks of the Solomon River and larger local creeks. These soils formed in alluvial deposits.

In a representative profile the surface layer is very dark grayish-brown silt loam about 15 inches thick. The subsoil is about 17 inches thick. The upper part of the subsoil is dark grayish-brown, friable light silty clay loam, and the lower part is grayish-brown, friable silt loam. The substratum is calcareous, light brownish-gray silt loam.

Hord soils have moderate permeability and a high available water capacity. These soils are productive and have high natural fertility. The hazard of erosion is slight.

Representative profile of Hord silt loam, about 2,200 feet west and 1,500 feet south of the northeast corner of sec. 26, T. 7 S., R. 12 W., in a cultivated area:

- A1—0 to 15 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine roots; many worm casts; slightly acid; gradual, smooth boundary.
- B2—15 to 26 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, subangular blocky structure; slightly hard, friable; many fine and medium roots; many worm casts; neutral; gradual, smooth boundary.
- B3—26 to 32 inches, grayish-brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; moderate, medium, subangular blocky structure; slightly hard, friable; many fine roots; many worm casts; many fine pores; scattered films and threads of free lime; slight effervescence; moderately alkaline; gradual, smooth boundary.
- C1—32 to 42 inches, light brownish-gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) moist; weak, medium, subangular blocky structure; slightly hard, friable; few fine roots; many fine pores; scattered worm casts; many films, threads, and small soft accumulations of lime; strong effervescence; moderately alkaline; clear, smooth boundary.
- C2—42 to 60 inches, light brownish-gray (10YR 6/2) heavy silt loam, grayish brown (10YR 5/3) moist; moderate to weak, medium, subangular blocky structure; slightly hard, friable; many fine pores; common films and threads of lime; strong effervescence; moderately alkaline.

The A horizon is 10 to 16 inches thick. When dry, it is dark grayish brown to grayish brown. The B horizons range from 16 to 26 inches in combined thickness. Depth to calcareous material ranges from 24 to 40 inches.

Hord soils are near McCook, Detroit, New Cambria, and Roxbury soils. They have a more clayey subsoil and are deeper to lime than McCook soils. They are less clayey than Detroit and New Cambria soils. Hord soils are deeper to lime than Roxbury soils.

**H<sub>z</sub>—Hord silt loam.** This soil is mainly on broad, high terraces of the North and South Forks of the Solomon River (fig. 16). Small areas are on the terraces of Twelve Mile, Indian, Covert, and Kill Creeks. The slope is 0 to 1 percent.

Included with this soil in mapping were small areas of McCook, Detroit, and Roxbury soils.

This Hord soil is well suited to all locally grown crops and grasses. It is also well suited to irrigation if water of suitable quality is available. Water erosion is a slight hazard, and soil blowing is a hazard if the



Figure 16.—Nearly level area of Hord silt loam that shows management of crop residue.

soil is not protected by growing plants or crop residue. Conservation of water is a concern of management during periods of low rainfall. Wheat, grain sorghum, forage sorghum, and corn are the main crops. (Capability unit I-1, Loamy Terrace range site, windbreak suitability group 1)

## Inavale Series

The Inavale series consists of deep, gently undulating to rolling, sandy, somewhat excessively drained soils. These soils formed in calcareous sand deposited on flood plains and low terraces that have been reworked by wind.

In a representative profile the surface layer is grayish-brown, calcareous loamy fine sand about 6 inches thick. The next layer is grayish-brown, loose, calcareous fine sand about 8 inches thick. The substratum is pale-brown, loose, calcareous sand.

Inavale soils have rapid permeability and a low available water capacity. They have a shallow effective root depth.

Representative profile of Inavale loamy fine sand, about 1,200 feet east and 2,740 feet north of the southwest corner of sec. 10, T. 7 S., R. 15 W., in range:

- A1—0 to 6 inches, grayish-brown (10YR 5/2) loamy fine sand, dark grayish brown (10YR 4/2) moist; slightly coherent clods that break easily to weak, granular structure and to single grains of sand; soft, loose; many fine roots; strong effervescence; mildly alkaline; gradual, smooth boundary.
- AC—6 to 14 inches, grayish-brown (10YR 5/2) fine sand, dark grayish brown (10YR 4/2) moist; single grained (structureless); loose; common fine roots; strong effervescence; mildly alkaline; diffuse, smooth boundary.
- C—14 to 50 inches +, pale-brown (10YR 6/3) fine sand, brown (10YR 5/3) moist; single grained (structureless); loose; few fine roots; strong effervescence; mildly alkaline.

The principal variation in these soils is in the depth of darkening in the A1 and AC horizons. Grayish-brown extends to a depth of 9 to 18 inches. The A1 and AC horizons range from 10 to 20 inches in combined thickness.



Figure 17.—Representative area of Inavale loamy fine sand. Low dunes are in the background.

Inavale soils are near Alluvial land, mixed, McCook soils, and Munjor soils. Inavale soils are more uniform in texture than Alluvial land, mixed, and lack the stratified silt loam, clay loam, and clay. The dark color does not extend to so great a depth as in McCook and Munjor soils, and they are more sandy than those soils.

**In—Inavale loamy fine sand.** This soil is on low, hummocky landscapes and in scattered areas of dunes. It is on the flood plains and low terraces of the North and South Forks of the Solomon River. The slope is 5 to 16 percent. In some places where the dunes occur, there are small blowouts that are a result of soil blowing. In other places, where the soil is adjacent to finer textured soils, it has a thin layer of sandy loam on the surface (fig. 17).

Included with this soil in mapping were a few small areas of McCook and Munjor soils. This Inavale soil is not suitable for cultivation, because it is coarse textured and subject to soil blowing. If the soil is well managed, however, it is suited to tall and mid grasses. Deferred grazing and proper use of the range will maintain and improve the natural vegetation, but blowing is a serious hazard unless the soil is protected. In areas that are overgrazed, blowing is likely to start and cactus and other weeds quickly invade. (Capability unit VIe-4, Sands range site, windbreak suitability group 4)

## McCook Series

The McCook series consists of deep, nearly level to gently undulating, well-drained soils on terraces of the North and South Forks of the Solomon River. These soils formed in alluvium.

In a representative profile the surface layer is dark grayish-brown, calcareous, coarse silt loam about 12 inches thick. The next layer is grayish-brown, calcareous, coarse silt loam about 6 inches thick. The upper part of the underlying material is light brownish-gray coarse silt loam that is stratified with silty clay loam and loam. The middle part is light-gray very fine sandy

loam that is stratified with sandy loam. Loamy sand is at a depth of about 47 inches.

McCook soils have moderate permeability and a high available water capacity. They are productive and can be easily worked throughout a wide range of moisture content. They are subject to soil blowing, however, and are slightly susceptible to water erosion.

Representative profile of McCook silt loam, about 2,400 feet west and 2,350 feet north of the southeast corner of sec. 23, T. 7 S., R. 12 W., in a cultivated field:

- A1—0 to 12 inches, dark grayish-brown (10YR 4/2) coarse silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine and medium roots; many worm casts; slight effervescence; moderately alkaline; gradual, smooth boundary.
- AC—12 to 18 inches, grayish-brown (10YR 5/2) coarse silt loam, dark grayish brown (10YR 4/2) moist; moderate, fine, granular structure; slightly hard, friable; many fine roots; many worm casts; much mixing of colors from horizons above by worm action; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C1—18 to 22 inches, light brownish-gray (10YR 6/2) coarse silt loam, dark grayish brown (10YR 4/2) moist; weak, fine, granular structure; slightly hard; friable; many fine roots; many worm casts; strong effervescence; moderately alkaline; clear, smooth boundary.
- C2—22 to 32 inches, light brownish-gray (10YR 6/2) coarse silt loam thinly stratified with light silty clay loam and loam, dark grayish brown (10YR 4/2) moist; weak, fine, granular structure; slightly hard, friable; common fine roots, scattered films and threads of lime; strong effervescence; moderately alkaline; clear, smooth boundary.
- C3—32 to 47 inches, light-gray (10YR 7/2) very fine sandy loam thinly stratified with sandy loam, grayish brown (10YR 5/2) moist; massive; friable; few fine roots; many worm casts; many fine pores; strong effervescence; moderately alkaline; abrupt, smooth boundary.
- IIC4—47 to 63 inches, light-gray (10YR 7/2) loamy sand, grayish-brown (10YR 5/2) moist; single grained; loose; strong effervescence.

The A1 horizon is 10 to 20 inches thick. In some places soil blowing has been slight and has changed the surface layer from coarse silt loam to loam or very fine sandy loam. The AC horizon is 5 to 15 inches thick. Sand is below a depth of 40 inches in some places.

McCook soils are near Hord, Inavale, and Munjor soils. In McCook soils lime is not leached to so great a depth as in the Hord soils, and they are coarser textured than those soils. They are darker to a greater depth and have less sand in the solum than Inavale and Munjor soils.

**Ma—McCook silt loam.** This soil is on the terraces of the North and South Forks of the Solomon River. The slope is 0 to 2 percent. Included with it in mapping were areas of soils that are similar to McCook soils, but the surface layer is not so dark. In some places small areas of Hord and Munjor soils were also included.

This McCook soil is well suited to all crops commonly grown in the county. Nearly all the acreage is in wheat, grain sorghum, or alfalfa. This soil is also well suited to irrigation if water of suitable quality is available. Soil blowing is a hazard if the soil is not protected by growing plants or crop residue. The main concerns of management are protecting the soil from blowing and conserving moisture. (Capability unit I-1, Loamy Terrace range site, windbreak suitability group 1)



## Mento Series

The Mento series consists of deep, gently sloping to sloping, well-drained soils on uplands. These soils formed in loess and material weathered from limestone or chalk.

In a representative profile the surface layer is dark grayish-brown silty clay loam about 6 inches thick. The subsoil is about 26 inches thick. The upper part of the subsoil is firm, dark grayish-brown heavy silty clay loam, and the lower part is firm, calcareous, brown silty clay loam that contains much free lime. The substratum is brown silty clay loam. White chalk or limestone is at a depth of about 48 inches.

Runoff is moderate in the less sloping areas of Mento soils and rapid in the more sloping areas. Permeability is slow, and the available water capacity is moderate. These soils are subject to water erosion. If they are cultivated, the surface puddles easily.

In Osborne County the Mento soils are mapped only in complexes with the Harney soils.

Representative profile of Mento silty clay loam in an area of Harney-Mento complex, 1 to 3 percent slopes, about 400 feet south and 450 feet west of the northeast corner of sec. 33, T. 7 S., R. 15 W., in a cultivated field:

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; very hard, firm; many fine roots; common worm casts; neutral; clear, smooth boundary.

B21t—6 to 12 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) moist; strong, medium and fine, blocky structure; extremely hard, firm; common fine roots, most of which follow ped faces; thin patchy films of clay; mildly alkaline; clear, smooth boundary.

B22tca—12 to 20 inches, brown (10YR 5/3) heavy silty clay loam, dark brown (10YR 4/3) moist; moderate, medium and fine, blocky structure; extremely hard, firm; common fine and medium roots; many, small, soft accumulations of lime that cover 25 to 30 percent of soil mass; many films and threads of lime; strong effervescence; moderately alkaline; gradual, smooth boundary.

B3ca—20 to 32 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; moderate, medium and fine, blocky structure; very hard, firm; many fine roots; many fine pores; common worm casts; many soft accumulations of lime, less abundant than in horizon above; strong effervescence; moderately alkaline; gradual, smooth boundary.

Cca—32 to 48 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; weak, coarse, sub-angular blocky structure; very hard, firm; very porous; few films and threads of gypsum; many films and threads of lime; violent effervescence; moderately alkaline; clear, wavy boundary.

IIR—48 to 60 inches, white chalk or soft limestone; somewhat weathered; fractured.

The solum is 20 to 40 inches thick. Depth to the underlying chalk or soft limestone is 40 to 60 inches. Depth to free lime ranges from 10 to 17 inches. The A horizon is silty clay loam to silt loam 5 to 9 inches thick. The B horizon and upper part of the C horizon contain 5 to 15 percent exchangeable sodium.

Mento soils are near Brownell, Harney, Heizer, Nuckolls, and Waken soils. They are deeper over limestone or chalk than Brownell, Heizer, or Waken soils. They have a more abrupt change between the A and B horizons than the Harney and Nuckolls soils, and they are not so deep to lime as those soils.

## Munjour Series

The Munjour series consists of deep, well-drained, calcareous, loamy soils that formed in alluvium. These soils are nearly level to gently undulating and are on the flood plain of the North and South Forks of the Solomon River.

In a representative profile the surface layer is light brownish-gray fine sandy loam about 11 inches thick. The next layer is about 17 inches thick. It is grayish-brown, very friable sandy loam that is thinly stratified with silt loam and loamy sand. The substratum is pale-brown fine sand.

Runoff is slow on the Munjour soils. Permeability is moderately rapid, and the available water capacity is low. These soils occasionally are subject to flooding. The water table is below a depth of 6 feet, except during periods of high streamflow.

In Osborne County the Munjour soils are mapped only in a complex with the McCook soils.

Representative profile of Munjour fine sandy loam in an area of the Munjour-McCook complex, about 2,300 feet east and 100 feet north of the southwest corner of sec. 5, T. 7 S., R. 14 W., in a cultivated field:

A1—0 to 11 inches, light brownish-gray (10YR 6/2) fine sandy loam thinly stratified with silt loam and loam, dark grayish brown (10YR 4/2) moist; moderate, medium, granular structure; soft, very friable; many fine roots; many worm casts that have mixed colors from horizon below; strong effervescence; moderately alkaline; gradual, smooth boundary.

C—11 to 28 inches, grayish-brown (10YR 5/2) sandy loam thinly stratified with silt loam and loamy sand, dark grayish brown (10YR 4/2) moist; weak, fine and medium, granular structure; soft, very friable; many fine roots; common worm casts; strong effervescence; moderately alkaline; gradual, smooth boundary.

IIC—28 to 40 inches, pale-brown (10YR 6/3) fine sand, brown (10YR 4/3) moist; single grained; loose; strong effervescence; moderately alkaline.

The A horizon is 4 to 14 inches thick. Depth to the IIC horizon ranges from 20 to 40 inches.

Munjour soils are less dark and are more sandy than McCook soils. They are near Inavale loamy fine sand and Alluvial land, mixed. Munjour soils are less sandy than the Inavale soils. They are more uniform in composition and are more sandy than Alluvial land, mixed.

**Mc—Munjour-McCook complex.** This complex is on the flood plain of the North and South Forks of the Solomon River. Its areas are elongated and irregularly shaped. The slope is 0 to 2 percent.

About 60 percent of the complex is Munjour fine sandy loam, and 40 percent is McCook silt loam. These soils are in areas so intermingled that mapping them separately was not practical.

The Munjour soil in this complex has the profile described as representative for the Munjour series, but in some places it has been covered with deposits of loamy sand 8 to 10 inches thick. The McCook soil has a profile similar to the one described as representative for that series, but in places it has a surface layer of fine sandy loam 7 to 10 inches thick.

Included with this complex in mapping were small areas of Inavale loamy sand that occur as streaks of sand across areas of this complex. Small areas of Alluvial land, mixed, also were included with it in some places.

This complex is suited to all crops commonly grown in the county. Nearly all of the complex is in wheat, alfalfa, grain sorghum, and forage sorghum. It also is suited to irrigation if water of suitable quality is available. Flooding is the main hazard to the soils of this complex. Water erosion and soil blowing are hazards when the soils are not protected. (Both soils, capability unit IIIw-1, windbreak suitability group 1; Munjor soil, Sandy Lowland range site; McCook soil, Loamy Lowland range site)

## New Cambria Series

The New Cambria series consists of deep, nearly level, moderately well drained clayey soils on terraces of the North and South Forks of the Solomon River and of the larger local creeks. These soils formed in clayey alluvial deposits.

In a representative profile the surface layer is dark-gray silty clay about 11 inches thick. The subsoil is dark-gray silty clay about 19 inches thick. This layer is very hard when dry and very sticky when wet, and it is calcareous. The substratum extends to a depth of about 60 inches. It has two parts; the upper part is dark-gray, calcareous silty clay, and the lower part is grayish-brown, calcareous silty clay loam.

New Cambria soils have slow permeability and a high available water capacity. Surface runoff is slow, and the hazard of erosion is low. These soils are productive, and they have high natural fertility.

Representative profile of New Cambria silty clay, about 1,000 feet north and 100 feet east of the southwest corner of sec. 1, T. 8 S., R. 12 W., in a cultivated area:

- Ap—0 to 7 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; moderate, fine, granular structure; very hard, firm; many fine roots; neutral; clear, smooth boundary.
- A1—7 to 11 inches, dark-gray (2.5Y 4/1) silty clay, very dark gray (2.5Y 3/1) moist; moderate, medium and fine, granular structure; very hard, firm; many fine roots; few scattered worm casts; neutral; gradual, smooth boundary.
- B2—11 to 30 inches, dark-gray (2.5Y 4/1) silty clay, very dark gray (2.5Y 3/1) moist; moderate, fine, blocky structure; very hard, firm; common fine roots; few scattered worm casts; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C1—30 to 40 inches, dark-gray (10YR 4/1) silty clay, very dark grayish brown (10YR 3/2) moist; moderate, fine, blocky structure; very hard, firm; common fine roots; many fine pores; few scattered worm casts; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C2—40 to 60 inches, grayish-brown (10YR 5/2) heavy silty clay loam, dark grayish brown (10YR 4/2) moist; moderate, medium and fine, subangular blocky structure; very hard, firm; many fine pores; few scattered worm casts; common segregated threads of lime and few, small, soft accumulations of lime; strong effervescence; moderately alkaline.

These soils generally are noncalcareous to a depth of 8 to 15 inches, but in some areas they are calcareous throughout. The A horizon is 9 to 15 inches thick. It is dominantly silty clay, but in some places it is silty clay loam. Depth to the more friable material in the C2 horizon ranges from 35 to 45 inches.

New Cambria soils are near Detroit, Hord, and Roxbury soils, but they have more clay throughout the surface layer and subsoil.

**Nc—New Cambria silty clay.** This soil is mainly on high terraces of the North and South Forks of the Solomon River and of the larger creeks in the county. It has the profile described as representative of the New Cambria series. The slope is 0 to 2 percent.

Included with this soil in mapping were a few areas of Detroit, Hord, and Roxbury soils. Also included are small areas, mostly where drainage is from shale, of soils that are like New Cambria soils, except that their substratum is silty clay to clay.

This soil is well suited to all crops commonly grown in the county. Nearly all the acreage is in wheat, grain sorghum, or alfalfa. Crops are sometimes damaged by too much moisture in periods of excessive rainfall because the subsoil is silty clay and the surface runoff is slow. In periods of low rainfall, however, conservation of water can be a concern of management. (Capability unit IIs-1, Clay Terrace range site, windbreak suitability group 1)

**Nd—New Cambria silty clay, frequently flooded.** This soil is on flood plains, 150 to 500 feet wide, within narrow upland drainageways. The slope is 0 to 2 percent.

Included with this soil in mapping were a few areas of Bogue and Timken soils on the fringes of the mapped areas. Also included were small areas of soils that are similar to New Cambria soils, but they are leached of lime to a depth of about 27 inches.

This soil is not suited to cultivation. It is well suited to grass, and nearly all the acreage is in native range. Flooding is the main hazard, and water erosion cuts channels along the surface. (Capability unit VIw-1, Clay Lowland range site, windbreak suitability group 1)

## Nibson Series

The Nibson series consists of strongly sloping to moderately steep, shallow, somewhat excessively drained, loamy soils on uplands. These soils formed in material weathered from calcareous, interbedded, chalky shale and soft limestone.

In a representative profile the surface layer is dark-gray silt loam about 8 inches thick (fig. 18). The subsoil is light-gray, friable silty clay loam about 6 inches thick. The surface layer and subsoil are calcareous and have fragments of limestone scattered throughout. The substratum is very pale brown silty clay loam, and it contains many fragments of limestone and shale that increase with depth. It is strongly calcareous. Very slightly weathered, interbedded chalky shale and soft limestone are at a depth of about 19 inches.

Nibson soils have moderate permeability and low available water capacity. Internal drainage is restricted by the underlying shale. These soils are highly productive when used for range. They have high natural fertility and a shallow effective root zone.

Representative profile of Nibson silt loam in an area of Nibson complex, about 2,590 feet south and 75 feet east of the northwest corner of sec. 29, T. 10 S., R. 11 W., in native grass:

- A1—0 to 8 inches, dark-gray (10YR 4/1) silt loam, very dark brown (10YR 2/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine and medium roots; many worm casts; few





Figure 18.—Representative profile of Nibson silt loam.

fragments of limestone scattered throughout; slight effervescence; moderately alkaline; gradual, wavy boundary.

B2—8 to 14 inches, light-gray (10YR 7/2) light silty clay loam, grayish brown (10YR 5/2) moist; mixing of colors from horizon above by worm action; moderate, medium, granular structure; slightly hard, friable; many fine roots; common worm casts; common fragments of limestone scattered throughout; strong effervescence; moderately alkaline; gradual, wavy boundary.

C1—14 to 19 inches, very pale brown (10YR 7/3) light silty clay loam; pale brown (10YR 6/3) moist; weak, medium, granular structure; slightly hard, friable; common fine roots; few worm casts; many fragments of limestone and shale scattered throughout and increasing with depth; thin coating of lime about 2 millimeters thick on underside of rock fragments; violent effervescence; strongly alkaline; clear, wavy boundary.

C2—19 to 24 inches, light-gray to very pale brown silty shale; strong, medium and coarse, platy structure; interbedded chalky shale and soft limestone; violent effervescence.

The A horizon ranges from gray to dark grayish brown when dry. The very dark grayish-brown layer is 7 to 10 inches thick. The B horizon ranges from silty clay loam to silt loam. Depth to unweathered chalky shale and soft limestone is 12 to 20 inches.

Nibson soils are near Armo and Corinth soils. These soils are underlain by chalky shales that the Armo soils lack. They are more gray, contain less clay, and have more fragments of limestone than Corinth soils.

**Nx—Nibson complex.** This complex is on convex, strongly sloping hilltops and moderately steep side slopes of upland drainageways. The slope is 8 to 20 percent.

About 65 percent of the complex is Nibson silt loam. Another 20 percent is similar to Nibson silt loam, but it is either less than 10 inches or more than 20 inches to unweathered limestone. The thinner soil is on steep side slopes where the more resistant limestone bedrock outcrops. The thicker soil is on the more gentle upper slopes. The remaining 15 percent is Armo silt loam in some places or Roxbury silt loam in others.

Nibson silt loam in this complex has the profile de-

scribed as representative for the series, but in the mapping area it is quite variable in horizon thickness and depth to bedrock.

Included with this complex in mapping were small areas of Armo soils on foot slopes of steep areas. Also included were small areas of Harney soils.

Most areas of this soil are used for grazing. This soil is naturally fertile, and it supports a good stand of native grasses. Careful management of grazing is needed to maintain good yields of forage. Proper stocking and deferred grazing are practices that maintain or improve native range. (Capability unit VIe-2, Limy Upland range site, windbreak suitability group 4)

### Nuckolls Series

The Nuckolls series consists of deep, sloping, well-drained soils on side slopes adjacent to upland drainageways. These soils formed in calcareous silty loess.

In a representative profile the surface layer is dark grayish-brown silt loam about 11 inches thick. The subsoil is friable, light silty clay loam about 24 inches thick. The upper part is dark brown, the middle part is brown, and the lower part is light brown. The subsoil contains soft accumulations of free lime at a depth of about 30 inches. The substratum is light-brown silt loam that contains much free lime.

Runoff is medium on the Nuckolls soils. Permeability is moderate, and the available water capacity is high. These soils respond well to phosphate fertilizer. They are subject to water erosion.

In Osborne County Nuckolls soils are mapped only with the Harney soils.

Representative profile of Nuckolls silt loam in an area of Harney-Nuckolls complex, 3 to 8 percent slopes, about 1,200 feet west and 750 feet north of the southeast corner of sec. 6, T. 9 S., R. 13 W., in native grass:

A1—0 to 11 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine and medium roots; many worm casts; neutral; gradual, smooth boundary.

B1—11 to 15 inches, dark-brown (7.5YR 4/2) light silty clay loam, dark brown (7.5YR 3/2) moist; moderate, medium, subangular blocky structure parting to moderate, medium, granular; slightly hard, friable; many fine and medium roots; common worm casts; some mixing of colors by worm action; mildly alkaline; gradual, smooth boundary.

B2—15 to 29 inches, brown (7.5YR 5/3) light silty clay loam, dark brown (7.5YR 4/3) moist; moderate, medium, subangular blocky structure; hard, friable; many fine and medium roots; common worm casts; some mixing of colors by worm action; mildly alkaline; gradual, smooth boundary.

B3—29 to 35 inches, light-brown (7.5YR 6/4) light silty clay loam, brown (7.5YR 5/4) moist; moderate, medium, subangular blocky structure; slightly hard, friable; many fine pores; scattered worm casts; scattered films and threads of lime increasing with depth; strong effervescence; moderately alkaline; gradual, smooth boundary.

C—35 to 60 inches, light-brown (7.5YR 6/4) silt loam, brown (7.5YR 5/4) moist; porous, massive; slightly hard, friable; few fine roots; scattered worm casts; common, small soft accumulations of lime and common films and threads of lime; strong effervescence; moderately alkaline.

In some places the profile is calcareous at the surface. The A horizon is dominantly silt loam, but it is light

silty clay loam in some places. In some places weathered limestone or shale is below a depth of 40 inches.

Nuckolls soils also are near Mento and Tobin soils. They have less clay in their subsoil and are more brown than Harney or Mento soils. They are not so stratified and darkened with depth as Tobin soils.

## Roxbury Series

The Roxbury series consists of deep, nearly level to sloping, well-drained calcareous soils on the terraces of upland drainageways and creeks. These soils formed in silty alluvial deposits.

In a representative profile the surface layer is calcareous silt loam about 30 inches thick. The upper part is dark gray, and the lower part is grayish brown. The subsoil is about 30 inches thick. It is dark-gray heavy silt loam in the upper part, and dark grayish-brown silt loam in the lower part. The substratum is grayish-brown silt loam. These soils are friable and easily worked.

Roxbury soils have moderate permeability and high available water capacity. These soils are productive and have high natural fertility. The hazard of erosion is low.

Representative profile of Roxbury silt loam, about 1,400 feet south and 800 feet west of the northeast corner of sec. 10, T. 8 S., R. 14 W., in a cultivated area:

- A11—0 to 18 inches, dark-gray (10YR 4/1) silt loam, very dark brown (10YR 2/2) moist; moderate, medium and fine, granular structure; slightly hard, friable; many fine roots; many worm casts; slight effervescence; mildly alkaline; gradual, smooth boundary.
- A12—18 to 30 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium and fine, granular structure; slightly hard, friable; many fine roots; many worm casts; strong effervescence; mildly alkaline; gradual smooth boundary.
- B2—30 to 42 inches, dark-gray (10YR 4/1) heavy silt loam, very dark brown (10YR 2/2) moist; moderate, medium, granular structure; slightly hard, friable; common fine roots; common worm casts; common films and threads of lime; strong effervescence; mildly alkaline; gradual, smooth boundary.
- Be—42 to 60 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; common fine roots; few worm casts; porous; strong effervescence; mildly alkaline; gradual, smooth boundary.
- C—60 to 72 inches, grayish-brown (10YR 5/2) heavy silt loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable; porous; many films and threads of lime; strong effervescence; moderately alkaline.

In some places the surface layer is light silty clay loam. The combined thickness of the A1 horizon ranges from 20 to 30 inches. In some places chips and pebbles of limestone are scattered throughout the soil profile.

Roxbury soils are near Detroit, Hord, New Cambria, and Tobin soils. They are less clayey than the Detroit or New Cambria soils. The depth to free lime is less in the Roxbury soils than in Hord and Tobin soils.

**Ro—Roxbury silt loam.** This soil is mostly on the terraces of the larger creeks. It has the profile described as representative for the Roxbury series. The slope is 0 to 2 percent. Included with this soil in mapping were small areas of Detroit, Hord, and Tobin soils.

This soil is well suited to all locally grown crops and

grasses. It also is suited to irrigation if water of suitable quality is available. Water erosion is a slight hazard. Soil blowing is a hazard if the soil is not protected by growing plants or crop residue. Conserving water can be a concern of management. (Capability unit I-1, Loamy Terrace range site, windbreak suitability group 1)

**Rp—Roxbury silt loam, channeled.** This soil is in shallow, entrenched, meandering drainageways across alluvial terraces. It is on the more sloping side slopes. The slope is 3 to 8 percent.

This Roxbury soil has a profile similar to the one described as representative for the Roxbury series, but the dark-colored surface layer is thinner.

Included with this soil in mapping were small areas of McCook, Detroit, and Hord soils.

Most of this soil is cultivated along with the surrounding soils. Water erosion and conservation of water are the main hazards, but soil blowing also occurs when the soils are not protected. In most places conservation practices are difficult to apply and maintain. (Capability unit IIIe-4, Loamy Terrace range site, windbreak suitability group 1)

**Rr—Roxbury complex.** This complex is on convex alluvial fans and foot slopes adjacent to more sloping uplands. The slope is 0 to 2 percent.

About 45 percent of the complex is Roxbury silt loam, and 40 percent is a soil that is similar to the Roxbury soil. The remaining 15 percent is Armo silt loam.

The soil in this complex that is similar to the Roxbury soil is stratified with thin layers of limestone chips, sand, and pebbles in the surface layer and subsoil.

Nearly all of this complex is cultivated. It is suited to all locally grown crops and grasses. It also is suited to irrigation if water of suitable quality is available. Water erosion is the main hazard on this soil. Soil blowing and conservation of water can be concerns of management. (Capability unit I-2, Loamy Terrace range site, windbreak suitability group 1)

## Timken Series

The Timken series consists of noncalcareous, shallow, strongly sloping to steep, moderately well drained soils. These soils are on shale uplands generally below the limestone hills. They formed in material weathered from acid shale.

In a representative profile the surface layer is gray clay about 4 inches thick. The next layer is very firm gray clay about 7 inches thick. The substratum is gray clay that contains some unweathered shale. It is underlain at a depth of about 16 inches by unweathered, gray clay shale.

Timken soils have a very low to low available water capacity and very slow permeability. Surface runoff is rapid. They have a shallow effective root zone.

Representative profile of Timken clay, in an area of Timken-Bogue clays, about 2,240 feet south and 150 feet east of the northwest corner of sec. 2, T. 10 S., R. 11 W., in native grass:

- A1—0 to 4 inches, gray (2.5Y 5/1) clay, dark gray (2.5Y 4/1) moist; moderate, medium, granular structure and some moderate, very fine, blocky; very hard,

- firm; many fine and medium roots; neutral; clear, smooth boundary.
- AC—4 to 11 inches, gray (2.5Y 5/1) clay; dark gray (2.5Y 4/1) moist; moderate, fine and very fine, blocky structure; very hard, very firm; many fine and medium roots; lower inch contains a few threads of gypsum; neutral; gradual, smooth boundary.
- C1—11 to 16 inches, gray (2.5Y 5/1) clay; dark gray (2.5Y 4/1) moist; weak, very fine, blocky structure mixed with medium and fine platy; very hard, very firm; common fine roots, few medium-sized roots tend to follow cleavage planes of structure; scattered, disoriented, partly weathered fragments of shale; few threads of gypsum; medium acid; gradual, smooth boundary.
- C2—16 to 60 inches, gray (2.5Y 5/0) clay shale; dark gray (2.5Y 4/1) moist; scattered strong-brown (7.5YR 5/6) surfaces of cleavage planes when dry; 1- to 4-inch layers of strong, very coarse, platy structure or laminated shale; very hard, very firm; very few coarse roots along cleavage planes to a depth of 49 inches; scattered thin layers of gypsum; very strongly acid.

The A1 horizon is 2 to 6 inches thick, and the AC horizon is 4 to 8 inches thick. Depth to unweathered shale ranges from 9 to 20 inches.

Timken soils are mapped with Bogue soils, but they are less deep to unweathered shale than Bogue soils. They also are near Armo, Corinth, and Heizer soils. Timken soils are less deep and more clayey than Armo soils. They are less brown than the Corinth soils, and they are not calcareous. The Heizer soils formed in material weathered from chalky limestone.

**Tb—Timken-Bogue clays.** This complex is on ridgetops and side slopes of drainageways. The slope is 8 to 30 percent. These soils are so intermingled that it was not practical to map them separately.

Timken soil makes up about 50 percent of the complex, and Bogue soil about 35 percent. The remaining 15 percent is Armo and New Cambria soils.

The Timken soil has the profile described as representative for the Timken series. Included with this complex in mapping were a few small areas of shale outcrops.

The soils in this complex are suited to grass. Careful management of grazing is needed to maintain good yields of forage. (Capability unit VIIs-2, Blue Shale range site, windbreak suitability group 4)

**Tm—Timken-Shale outcrop complex.** This complex is on side slopes of drainageways generally in areas of Timken-Bogue clays. The slope is 8 to 30 percent.

About 60 percent of the complex is slightly weathered to unweathered shale, and about 30 percent is Timken soil. The remaining 10 percent is Bogue soil in some places or Armo soil in others. The barren outcrop of shale is the result of geologic erosion. This shale is dark gray, and it is acid. Many, large, calcareous, septarian concretions are exposed by slides and entrenching drainageways.

The soils in this complex are used along with soils in adjoining range areas. They have little value for range. The sparse vegetation consists of big and little bluestems. (Capability unit VIIs-2, Blue Shale range site, windbreak suitability group 4)

## Tobin Series

The Tobin series consists of deep, nearly level, noncalcareous, well-drained soils on narrow flood plains of

upland drainageways. They formed in silty alluvial deposits.

In a representative profile the surface layer is grayish-brown and dark-gray silt loam about 20 inches thick. The next layer is dark grayish-brown light silty clay loam about 10 inches thick. It is friable and calcareous. The substratum is grayish-brown light silty clay loam and silt loam that becomes brown with depth.

Tobin soils have moderate permeability and high available water capacity.

Representative profile of Tobin silt loam in an area of Tobin and Roxbury silt loams, about 200 feet east and 150 feet south of the northwest corner of sec. 10, T. 8 S., R. 12 W., in a cultivated field:

- A11—0 to 10 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; stratified, moderate, medium, granular structure and weak, fine, granular structure; slightly hard, friable; many fine and medium roots; common worm casts; neutral; clear, smooth boundary.
- A12—10 to 20 inches, dark-gray (10YR 4/1) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine roots; many worm casts; neutral; gradual, smooth boundary.
- AC—20 to 30 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; common fine roots; many fine pores; common worm casts; slight effervescence; mildly alkaline; many films and threads of lime, scattered small accumulations of lime; gradual, smooth boundary.
- C1—30 to 45 inches, grayish-brown (10YR 5/2) light silty clay loam, very dark grayish brown (10YR 3/2) moist; medium, fine, subangular blocky structure; slightly hard; friable; few fine roots; many fine pores; scattered films, threads, and small accumulations of lime; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C2—45 to 60 inches, brown (10YR 5/3) silt loam, dark brown (10YR 4/3) moist; structureless; slightly hard; friable; few fine roots; many fine pores; common films and threads of lime; strong effervescence; moderately alkaline.

In some places the A1 horizon is light silty clay loam. The A11 and A12 horizons range from 14 to 24 inches in combined thickness. Depth to calcareous material ranges from 15 to 36 inches, but in some places it is as deep as 43 inches. Weakly defined strata that vary in texture and color are common throughout.

Tobin soils are near Harney, Nuckolls, and Roxbury soils. Tobin soils are darker to a greater depth than Harney or Nuckolls soils. They are noncalcareous to a greater depth than Roxbury soils.

**Tr—Tobin and Roxbury silt loams.** These undifferentiated soils are in narrow upland drainageways. They are joined or separated in no definite pattern from one area to another. Not every delineated area contains both soils. The slope is 0 to 2 percent.

The Tobin soil has the profile described as representative for the Tobin series. Included with these soils in mapping were small areas of Detroit and Hord soils.

These soils are used for crops and range. They are well suited to all crops commonly grown in the county. They are subject to flooding during any season of the year. The flooding causes only slight damage to these soils in most years, but in some years it causes serious scour damage or deposit sediments. Watershed improvement helps control flooding in these areas. (Capability unit IIw-1, Loamy Lowland range site, windbreak suitability group 1)

## Wakeen Series

The Wakeen series consists of moderately deep, sloping to moderately steep, calcareous, well-drained loamy soils on uplands. These soils formed in material weathered from chalk or soft limestone.

In a representative profile the surface layer is dark-gray silt loam about 10 inches thick. The subsoil is pale-brown, friable silty clay loam about 10 inches thick. The substratum is very pale brown silty clay loam, and it contains fragments of unweathered chalk. Very pale brown chalky limestone is at a depth of about 34 inches. These soils are calcareous throughout (fig. 19).

Runoff is medium to rapid on the Wakeen soils. These soils have moderate permeability and a moderate to low available water capacity. They are subject to water erosion.

In Osborne County the Wakeen soils are mapped only in a complex with Brownell and Mento soils.

Representative profile of Wakeen silt loam, in an area of Brownell-Wakeen complex, about 2,400 feet west and 150 feet south of the northeast corner of sec. 28, T. 8 S., R. 15 W., in a cultivated area:

- A1—0 to 10 inches, dark-gray (10YR 4/1) silt loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, granular structure; slightly hard, friable; many fine roots; common worm casts; scattered small fragments of limestone; strong effervescence; moderately alkaline; gradual, smooth boundary.
- B2—10 to 20 inches, pale-brown (10YR 6/3) silty clay loam, brown (10YR 5/3) moist; moderate, medium, subangular blocky structure parting to moderate, medium, granular; hard, friable; many fine roots; many worm casts; scattered fragments of limestone; scattered accumulations of soft lime in lower 2 inches; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C1—20 to 34 inches, very pale brown (10YR 7/3) silty clay loam, light yellowish brown (10YR 6/4) moist; moderate, coarse, subangular blocky structure; fragments of unweathered shale scattered throughout; hard, friable; few fine roots; scattered

worm casts; porous; violent effervescence; moderately alkaline; gradual, smooth boundary.

C2—34 to 48 inches, very pale brown (10YR 8/3) chalky limestone, (10YR 7/4) moist; weak bedding planes; violent effervescence; strongly alkaline.

The A horizon is 7 to 15 inches thick, and the B horizon is 6 to 15 inches thick. Depth to unweathered chalky shale or soft limestone ranges from 20 to 36 inches. Thin strata of limestone pebbles are in the A or B horizons in some places.

Wakeen soils are near Armo, Brownell, Heizer, and Mento soils. Wakeen soils have fewer fragments of limestone and other rock in their surface and subsurface layers than Brownell and Heizer soils. They are thicker over limestone than Heizer soils, and they are not so deep or so clayey as Mento soils. Armo soils, unlike Wakeen soils, have no chalky shale within a depth of 40 inches.

### Wm—Wakeen-Mento complex, 3 to 8 percent slopes.

This complex is on side slopes of uplands and on the enclosed, narrow valley floor of small drainageways.

About 40 percent of the complex is Wakeen silt loam, 25 percent is Mento silty clay loam, 15 percent is barren outcrops of shale, and 20 percent is Harney and Roxbury soils.

Included with this complex in mapping were small eroded areas. These areas are cut by gullies and numerous shallow rills. They are shown on the detailed soil map by the symbol for a severely eroded spot.

Most of this complex is cultivated along with the surrounding soils. Water erosion is the main concern of management. Soil blowing occurs where the soil is not protected. Other concerns are poor surface tilth and low fertility. When cultivated, the surface layer seals over and crusts easily after rain. These soils are not suitable for growing cultivated crops year after year. In most places conservation practices are difficult to apply and maintain. (Both soils, capability unit IVE-2, Limy Upland range site; Wakeen soil, windbreak suitability group 3; Mento soil, windbreak suitability group 2)

## Use and Management of the Soils

The soils of Osborne County are used extensively for cultivated crops and native range. This section explains how the soils can be managed for these uses and for windbreaks, wildlife habitat, and use as sites for recreation facilities, highways, farm ponds, and other engineering structures. Predicted yields of the principal crops under an improved level of management are also given. For the names of soils in each of the interpretative groups refer to the "Guide to Mapping Units" at the back of this survey.

### Management of Soils for Dryfarmed Crops<sup>2</sup>

In Osborne County the soils used for dryfarmed crops need management practices that help reduce water erosion and soil blowing, help maintain good soil structure and an adequate organic-matter content, and help conserve as much rainfall as possible. Erosion control and water conservation are more effective if a proper combination of practices is used.

Grassed waterways (fig. 20), terraces, and contour

<sup>2</sup> RODNEY F. HARNER, soil scientist, Soil Conservation Service, helped prepare this section.



Figure 19.—Representative profile of Wakeen silt loam.



**Figure 20.**—Grassed waterway in an area of Harney-Nuckolls complex, 3 to 8 percent slopes.

farming can help reduce water erosion and conserve moisture on the sloping soils in the county. These practices, alone or combined, also can be helpful on some nearly level soils that have long slopes. Each row planted on the contour serves as a miniature terrace by holding back water and letting it soak into the soil. The water saved by terracing and contour farming increases crop growth, which adds to the amount of residue available for protecting the soil.

Proper management of crop residues on all soils in the county helps maintain good soil structure, improve absorption of water, and control water erosion and soil blowing. A cover of residue on the surface helps hold the soil in place and reduces the puddling effect of raindrops.

Minimum or reduced tillage helps prevent the breakdown of soil aggregates and retain more residue on the surface. Tilling when the soil is too wet causes a tillage pan to form, particularly in loam and silt loam soils.

Stripcropping also can be used to control soil blowing. It is generally used with good management of crop residue, minimum tillage, and a good system of maintaining soil fertility. Stripcropping is especially helpful on some nearly level soils that have a surface layer of sandy loam or loam.

Wheat and grain sorghum are the major crops in Osborne County. Some alfalfa is grown, mainly on bottom lands and some on uplands. Forage sorghum also is grown. The crop sequence affects the combination of practices needed on a particular soil. Close-growing crops, such as wheat, provide more protection for the soil than row crops. The residue from wheat also provides more protection than that from grain sorghum.

### Management of Soils for Irrigated Crops<sup>3</sup>

The factors to consider in planning an irrigation system are (1) the characteristics and properties of

<sup>3</sup> RODNEY F. HARNER, soil scientist, Soil Conservation Service, helped prepare this section.

the soil, (2) the quality and quantity of irrigation water available, (3) the crops to be irrigated, and (4) the type of system to be used for irrigation. It is especially important to know the quality of the water so that the long-time effect of irrigation on a soil can be evaluated. All water used for irrigation contains some soluble salts. If water of poor quality is used on a soil that has slow permeability, harmful salts are likely to accumulate in the soil if there is little or no leaching. An application of water in excess of the needs of crops is needed so that some of the water passes through the root zone.

Some soil characteristics that must be considered in designing an irrigation system are depth, available water capacity, permeability, drainage, slope, and susceptibility to stream overflow. The frequency of irrigation depends on the crop needs and the available water capacity of the soil. The available water capacity is determined mainly by the depth and texture of the soil. Permeability affects the rate at which water enters the soil and also the internal drainage. The rate of water intake is also affected by the condition of the surface layer.

Wheat, grain sorghum, and alfalfa are the main crops grown under irrigation in Osborne County (fig. 21). In the section "Engineering Uses of Soils," permeability and the available water capacity are listed for each soil, and the features affecting the use of soils for irrigation are given.

### Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops (9). The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not apply to special crops that have their own requirements for economical production. The soils are grouped according to degree and kind of per-





**Figure 21.**—Nearly level, irrigated area of Hord silt loam.

manent limitations, but the grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor possible but unlikely major reclamation.

In the capability system, the kinds of soils are grouped at three levels: the capability class, subclass, and unit. These are discussed in the following paragraphs.

**CAPABILITY CLASSES**, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. In class VII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

**CAPABILITY SUBCLASSES** are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion; *w* shows that water on or in the soil interferes with plant growth or cultivation; *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* shows that the chief limitation is climate that is too cold or too dry.

**CAPABILITY UNITS** are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management.

Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIe-3.

In short, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

The capability classification of the soils in Osborne County is given in the Guide to Mapping Units at the end of this survey. The eight classes in the capability system, and the subclasses and units in this county, when the soils are grouped for dryland farming, are described in the list that follows.

**Class I.** Soils have few limitations that restrict their use.

Unit I-1.—Deep, nearly level, well-drained loamy soils; on stream terraces.

Unit I-2.—Deep, nearly level to gently sloping, well-drained, loamy soils; on valley fans.

Unit I-3.—Deep, nearly level, moderately well drained, loamy soils; on stream terraces.

**Class II.** Soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Subclass IIe.—Soils are subject to moderate erosion if they are not protected.

Unit IIe-1.—Deep, gently sloping, well-drained, loamy soils; on uplands.



- Unit IIe-2.—Deep, gently sloping, well-drained, light clayey soils that are high in sodium; on uplands.
- Subclass IIw. Soils have moderate limitations because of excess water.
- Unit IIw-1. Deep, nearly level, well-drained, loamy soils; on flood plains.
- Subclass IIs. Soils have moderate limitations of water capacity or tilth.
- Unit IIs-1.—Deep, nearly level, moderately well drained, clayey soils; on stream terraces.
- Subclass IIc. Soils have climate limitations such as low rainfall, high evaporation, low humidity, high winds, and abrupt changes in temperature.
- Unit IIc-1.—Deep, nearly level, well-drained, loamy soils; on uplands.
- Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Subclass IIIe. Soils are subject to severe erosion if they are cultivated and not protected.
- Unit IIIe-1.—Deep, sloping, well-drained, loamy soils; on uplands.
- Unit IIIe-2.—Deep, sloping, well-drained, light clayey soils and soils that are high in sodium; on uplands.
- Unit IIIe-3.—Deep, sloping, well-drained, loamy soils that are high in lime; on uplands.
- Unit IIIe-4.—Deep, sloping, well-drained, loamy soils; on stream terraces.
- Subclass IIIw. Soils have severe limitations because of excess water.
- Unit IIIw-1.—Deep, nearly level to gently undulating, loamy soils; on flood plains.
- Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.
- Subclass IVe. Soils are subject to very severe erosion if they are cultivated and not protected.
- Unit IVe-1.—Deep, sloping, well-drained, loamy soils; on uplands.
- Unit IVe-2.—Moderately deep and deep, sloping, well-drained loamy soils; on uplands.
- Unit IVe-3.—Deep, sloping, well-drained, loamy soils that are eroded; on uplands.
- Unit IVe-4.—Moderately deep over shale, sloping, well-drained, clayey soils that are high in lime; on uplands.
- Subclass IVw. Soils have very severe limitations for cultivation because of excess water.
- Unit IVw-1.—Moderately deep and deep, nearly level to undulating soils of mixed texture; on flood plains.
- Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat (none in Osborne County).
- Class VI. Soils have severe limitations that make them generally unsuited to cultivation and restrict their use largely to range, woodland, or wildlife habitat.
- Subclass VIe. Soils are severely limited, chiefly by risk of erosion, if protective cover is not maintained.
- Unit VIe-1.—Deep and moderately deep, sloping to moderately steep, loamy and clayey soils; on uplands.
- Unit VIe-2.—Moderately deep and shallow, strongly sloping to moderately steep, loamy soils over limestone; on uplands.
- Unit VIe-3.—Moderately deep, strongly sloping to moderately steep, clayey soils that are high in lime and are over shale; on uplands.
- Unit VIe-4.—Deep, gently undulating to rolling, somewhat excessively drained, sandy soils; on stream terraces.
- Subclass VIw. Soils are severely limited by excess water and generally are not suitable for cultivation.
- Unit VIw-1.—Deep, nearly level, clayey soils; on narrow upland drainageways.
- Unit VIw-2.—Deep, nearly level to steep, loamy soils; on narrow drainageways and on flood plains by streams.
- Class VII. Soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to range, woodland, or wildlife habitat.
- Subclass VIIs. Soils are very severely limited by a shallow root zone, low moisture capacity, stones, or other soil features.
- Unit VIIs-1.—Shallow and moderately deep, strongly sloping to steep, loamy soils over limestone; on uplands.
- Unit VIIs-2.—Shallow and moderately deep, strongly sloping to steep, clayey soils over shale; on uplands.
- Class VIII. Soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or for esthetic purposes (none in Osborne County).

## Predicted Yields

Table 2 gives the predicted average yields of the principal dryland crops grown on the soils suited to cultivation. It shows the yields per acre that are expected over a period of years, but the yields do not apply to any given field in any particular year. They are based on information obtained from interviews with farmers and agricultural workers and from records of yields on test plots managed by the Kansas Agricultural Experiment Station at Fort Hays.

Crop yields vary widely and are greatly affected by management practices, weather, and damage from insects or diseases. In predicting yields, the effects of all factors except management were minimized. These predictions are for yields expected under a high level of management, that is, management used by farmers when they apply most of the latest proved practices. Generally, these practices help protect the soil from erosion and help conserve water. They include terracing, contour farming, using minimum tillage, planting suited crop varieties, and controlling weeds and insects. Also included are good management of crop residue and proper use of fertilizer.

TABLE 2.—*Predicted average yields per acre*

[Only the soils suited to cultivation are listed]

Soil	Wheat	Grain sorghum	Forage sorghum	Alfalfa
	<i>Bushels</i>	<i>Bushels</i>	<i>Tons</i>	<i>Tons</i>
Alluvial land, mixed -----	16	30	6	1.5
Armo silt loam, 3 to 7 percent slopes -----	24	34	7	2.0
Armo silt loam, 3 to 7 percent slopes, eroded -----	20	29	6	1.5
Corinth silty clay loam, 3 to 7 percent slopes -----	20	30	6	1.5
Detroit silty clay loam -----	32	54	11	3.5
Harney silt loam, 0 to 1 percent slopes -----	34	52	10	3.0
Harney silt loam, 1 to 3 percent slopes -----	30	50	10	3.0
Harney silt loam, 3 to 7 percent slopes -----	26	45	9	2.5
Harney silty clay loam, 2 to 7 percent slopes, eroded -----	22	39	8	2.0
Harney-Mento complex, 1 to 3 percent slopes -----	22	40	8	2.0
Harney-Mento complex, 3 to 7 percent slopes -----	20	30	6	1.5
Harney-Nuckolls complex, 3 to 8 percent slopes -----	22	35	7	1.5
Hord silt loam -----	36	60	12	4.0
McCook silt loam -----	31	50	10	3.5
Munjoy-McCook complex -----	26	45	9	2.5
New Cambria silty clay -----	28	48	10	3.0
Roxbury silt loam -----	34	60	12	3.5
Roxbury silt loam, channeled -----	28	35	7	1.5
Roxbury complex -----	30	50	10	3.0
Tobin and Roxbury silt loams -----	30	60	12	3.0
Wakeen-Mento complex, 3 to 8 percent slopes -----	18	30	6	1.5

### Management of Soils for Range<sup>4</sup>

In Osborne County much of the farm income is from the sale of livestock and livestock products. According to the 1969 Farm Facts from Kansas Crop and Livestock Information, about 40 percent of the annual gross income from farms and ranches in the county was from the sale of beef cattle, sheep, and dairy products. The number of cattle, including calves, in the county generally ranges from 46,000 to 68,000.

The major source of livestock feed is from native range, but large amounts of crops and their by-products are used for supplemental feed. About 41 percent of the county, or 220,400 acres, is used for range.

#### Range sites and condition classes

Effective range management includes knowing the capabilities of the various soils, the combinations of plants that can be produced, and the effects of grazing on the different kinds of plants. Recognizing the signs of a deteriorating range is helpful. A system for making an inventory and evaluating range resources is discussed in the following paragraphs.

*Range sites* are distinctive areas of range that differ from each other in ability to produce native vegetation, because they have a particular combination of soils, climate, and topography. Because the county has no significant differences in climate and elevation, the soils are grouped in range sites on the basis of differences in soil characteristics, such as depth, texture, and salinity, or in topography. Each range site produces a characteristic type of climax vegetation, and generally each site needs a particular system of management to keep it productive (fig. 22).

<sup>4</sup> By HARLAND E. DIETZ, range conservationist, Soil Conservation Service.

*Climax vegetation* is the most productive combination of plants that maintain themselves on a range site under natural climatic conditions. Continual excessive grazing alters this original plant cover, or climax vegetation, and lowers productivity.

Livestock graze selectively and constantly seek the more palatable plants. Unless grazing is regulated, the better plants are weakened and gradually decrease in number. These plants are called *decreasers*. *Increasers* are plants that begin to spread as the decreasers decline. Increasers generally are less productive and less palatable than decreasers. If heavy grazing continues, the increaser plants also weaken and decline in number. They are replaced by less desirable grasses and



Figure 22.—This livestock pond improves the distribution of grazing on Heizer-Brownell complex. The landscape is a combination of Shallow Limy and Limy Upland range sites in excellent condition.

weeds not native to the site; these plants are called *invaders*.

As the plants in a range site change from decreasers to increasers and then invaders, the productivity and general health of the range declines. This decline is generally systematic under heavy grazing, and it is expressed as the *range condition*. Four classes of range condition, described in the following paragraphs, show the degree to which a range has deteriorated from its potential climax vegetation.

A range site is in *excellent* condition if 76 to 100 percent of the present vegetation is the same composition as the original vegetation. Decreasers are dominant, and forage production is near the maximum for the site. The plant cover encourages intake of moisture and provides excellent protection against erosion.

The range site is in *good* condition if 51 to 75 percent of the present vegetation is the same composition as the original vegetation. A few of the decreasers have been grazed out and replaced by increasers, but the general productivity of the site is still good.

A range site is in *fair* condition if 26 to 50 percent of the present vegetation is the same composition as the original vegetation. Production of palatable forage is well below the potential for the site, because increasers are dominant and weeds are invading.

A range site is in *poor* condition if less than 25 percent of the present vegetation is the same composition as the original vegetation. Invaders and increasers are abundant, and very few decreasers remain. Productivity is unsatisfactory.

Range sites in poor or fair condition should be improved. To encourage the growth of the best climax forage plants, it is important to determine the condition of the range site and regulate grazing.

### **Descriptions of range sites**

The soils of Osborne County are grouped in range sites according to their ability to produce similar kinds and amounts of climax vegetation. The description of each range site gives important characteristics of the soils, estimates of potential yields, and a listing of the principal decreaser, increaser, and invader plants. To find the names of the soils in a range site, refer to the "Guide to Mapping Units" at the back of this soil survey.

#### **BLUE SHALE RANGE SITE**

This site consists of sloping to steep soils on uplands that have generally smooth, convex slopes. These soils are shallow to moderately deep and are clay throughout. Cracks are common in the subsoil and allow deep penetration of water and plant roots. Nevertheless, because permeability is very slow, the growth of plant roots is restricted. The available water capacity is low. Unless grazing is carefully managed, water erosion and soil blowing are severe hazards on these soils. Bogue and Timken soils make up this range site.

In the climax plant community, about 70 percent of the total annual production consists of decreasers such as side-oats grama, western wheatgrass, big bluestem, Illinois bundleflower, slimflower scurfpea, and dotted gayfeather. The principal increasers are blue grama, buffalograss, tall dropseed, red three-awn, western ragweed, and common pricklypear. Common invaders are silver bluestem, annual brome, and annual three-awn.

The production of western wheatgrass is high in years when precipitation is high in winter and spring. Likewise, the production of this grass is low if drought prevails in winter and spring.

When this site is in excellent condition, the average annual yield of air-dry herbage is 3,000 pounds per acre in years of favorable moisture. The yield is 800 pounds per acre in years of unfavorable moisture.

#### **CLAY LOWLAND RANGE SITE**

New Cambria silty clay, frequently flooded, is the only soil in this range site. It is a nearly level lowland soil that has a firm clayey subsoil. It absorbs water slowly and is moderately well drained.

In the climax plant community, at least 70 percent of the total annual production consists of decreaser grasses such as little bluestem, indiagrass, switchgrass, Canada wildrye, and big bluestem. The principal increasers include western wheatgrass, tall dropseed, blue grama, and side-oats grama; and the common invaders are saltgrass, buffalograss, silver bluestem, ironweed, and western ragweed.

The production of forage is high in years of abundant rainfall. It drops sharply during periods of drought. If this site is in excellent condition, the average annual yield is 5,000 pounds of air-dry herbage per acre in years of favorable moisture and 3,500 pounds per acre in years of unfavorable moisture.

#### **CLAY TERRACE RANGE SITE**

New Cambria silty clay is the only soil in this site. It is a nearly level soil on alluvial benches or terraces. The areas receive runoff from nearby uplands, but flooding is infrequent. This soil formed in deep alluvium and has a surface layer of silty clay loam to silty clay and a subsoil of light silty clay to dense clay. The subsoil is slowly permeable and restricts the growth of roots. The available water capacity is moderate to high.

In the climax plant community, about 60 percent of the total annual production consists of tall and mid grasses. These grasses are decreasers and include big bluestem, little bluestem, switchgrass, indiagrass, wildrye, and other perennial forbs and grasses. The principal increasers are side-oats grama, tall dropseed, blue grama, western wheatgrass, and western ragweed. Common invaders are annual brome, windmillgrass, tumblegrass, and little barley.

If this site is in excellent condition, the average annual yield is 4,500 pounds of air-dry herbage per acre in years of favorable moisture. The yield is 2,000 pounds per acre in years of unfavorable moisture.

#### **CLAY UPLAND RANGE SITE**

This site consists of gently sloping to sloping soils on uplands. These soils have a clayey subsoil that absorbs water slowly and restricts the growth of roots. When rainfall is below normal, these soils are droughty. Mento soils are in this range site.

In the climax plant community, at least 60 percent of the total annual production consists of a mixture of decreaser grasses. These include western wheatgrass, blue grama, buffalograss, tall dropseed, side-oats grama, and other perennial grasses and forbs. The principal increasers are blue grama, buffalograss, and western ragweed. And the common invaders are broomweed, annual three-awn, red three-awn, tumblegrass, annual brome, and little barley.

If this site is in excellent condition, the average annual yield is 3,000 pounds of air-dry herbage per acre in years of favorable moisture. The yield is 1,000 pounds per acre in years of unfavorable moisture.

#### LIMY UPLAND RANGE SITE

This site consists of sloping to moderately steep soils on uplands. These soils are deep, moderately deep, and shallow. The surface layer typically is calcareous and well granulated. These soils absorb water well, and the available moisture capacity is good. Armo, Brownell, Corinth, Nibson, and Wakeen soils make up this range site.

In the climax plant community, at least 80 percent of the total annual production consists of a mixture of decreaser grasses, shrubs, and forbs such as big bluestem, little bluestem, indiangrass, and switchgrass. Important legumes and forbs are leadplant, prairie-clover, catclaw, sensitivebriar, and blacksamson. The principal increasers are side-oats grama, blue grama, western wheatgrass, buffalograss, and prairie sage-wort. The common invaders are windmillgrass, tumblegrass, and annual brome.

If this site is in excellent condition, the average annual yield is 4,000 pounds of air-dry herbage per acre in years of favorable moisture. The yield is 1,000 pounds per acre in years of unfavorable moisture.

#### LOAMY LOWLAND RANGE SITE

This site consists of nearly level to steep soils on broken bottom lands along the rivers and major streams throughout the county. These soils have a loamy surface layer. They are deep, and root growth is not restricted. The available moisture capacity is high. Roxbury, Tobin, and McCook soils and Alluvial land, loamy, and Alluvial land, mixed, make up this range site.

In the climax plant community, 70 to 90 percent of the total annual production consists of a mixture of warm-season decreasers, including big bluestem, indiangrass, switchgrass, little bluestem, and prairie cordgrass. Natural stands of elm, cottonwood, willow, and hackberry grow along streambanks. Canada wild-rye, Virginia wildrye, and other shade-tolerant, cool-season grasses grow under the canopy of these trees. The principal increasers are western wheatgrass, tall dropseed, side-oats grama, ironweed, and blue grama; and the common invaders are Kentucky bluegrass, cocklebur, and silver bluestem.

If this site is in excellent condition, the average annual yield is 6,000 pounds of air-dry herbage per acre in years of favorable moisture. The yield is 3,500 pounds per acre in years of unfavorable moisture.

#### LOAMY TERRACE RANGE SITE

This site consists of nearly level to sloping alluvial soils on benches or terraces. Flooding is infrequent, but the areas receive runoff from nearby uplands. These soils have a surface layer and subsoil of silt loam to silty clay loam. They are deep and permeable and root growth is not restricted. Detroit, Hord, and Roxbury soils and McCook silt loam make up this site.

In the climax plant community, about 70 percent of the total annual production consists of tall and mid grasses. These grasses are decreasers such as big blue-

stem, little bluestem, switchgrass, indiangrass, and Canada wildrye. The principal increasers are western wheatgrass, tall dropseed, blue grama, side-oats grama, buffalograss, and western ragweed. Common invaders are annual brome, windmillgrass, silver bluestem, tumblegrass, and little barley.

If this site is in excellent condition, the average annual yield is 4,500 pounds of air-dry herbage per acre in years of favorable moisture. The yield is 2,500 pounds per acre in years of unfavorable moisture.

#### LOAMY UPLAND RANGE SITE

This site consists of nearly level to sloping soils on uplands. These soils have a loamy surface layer and a loamy to clayey subsoil. They are moderately to slowly permeable and have a high available water capacity. They are deep, and root growth is not restricted. Harney and Nuckolls soils make up this range site.

In the climax plant community, at least 50 percent of the total annual production consists of a mixture of decreasers such as little bluestem, big bluestem, side-oats grama, and switchgrass. Other perennial grasses and forbs make up the rest. The principal increasers are blue grama, western wheatgrass, tall dropseed, buffalograss, and forbs such as prairie coneflower, prairie sage-wort, slimflower scurfpea, and western ragweed. Common invaders are annual three-awn, annual brome, windmillgrass, silver bluestem, and red three-awn.

If this site is in excellent condition, the average annual yield is 4,000 pounds of air-dry herbage per acre in years of favorable moisture. The yield is 1,000 pounds per acre in years of unfavorable moisture.

#### SANDS RANGE SITE

Inavale loamy fine sand is the only soil in this range site. It is a gently undulating to rolling soil. It is deep and has a surface layer and subsoil of loamy fine sand. It absorbs moisture rapidly but has a low available water capacity.

In the climax plant community, at least 70 percent of the total annual production consists of a mixture of decreaser grasses, including sand bluestem, little bluestem, indiangrass, switchgrass, and sand lovegrass. Other perennial grasses, forbs, and shrubs make up the rest. The principal increasers are sand dropseed, fall witchgrass, prairie sage-wort, Scribner panicum, sand paspalum, and blue grama. Common invaders are sand-bur, annual eriogonum, camphorweed, and western ragweed.

If this site is in excellent condition, the average annual yield is 4,000 pounds of air-dry herbage per acre in years of favorable moisture. The yield is 2,500 pounds per acre in years of unfavorable moisture.

#### SANDY LOWLAND RANGE SITE

Munjoy is the only soil in this range site. It is a nearly level to gently undulating soil on the flood plains of the Solomon River. It is a deep soil and has a surface layer of sandy loam and a coarse subsoil. Permeability is moderately rapid. If they are not protected, the areas are highly subject to wind erosion.

In the climax plant community, about 70 percent of the total annual production consists of tall and mid grasses. These are decreasers and include sand blue-

stem, little bluestem, switchgrass, and indiangrass. Other perennial forbs and grasses make up the rest of the plant community. The principal increasers are sand dropseed, blue grama, and western wheatgrass. Common invaders are sandbur, annual three-awn, annual brome, and windmillgrass. Willow and cottonwood are common along stream banks.

If this site is in excellent condition, the average annual yield is 4,500 pounds of air-dry herbage per acre in favorable years. The yield is 3,500 pounds in years of unfavorable moisture.

#### SHALLOW LIMY RANGE SITE

Heizer is the only soil in this range site (fig. 23). It is a strongly sloping to steep soil on uplands. It has a loamy surface layer that ranges from 4 to 20 inches deep over limestone. Permeability is moderate, and the available water capacity is low. Root growth is restricted. The landscape is rough and is broken with many vertical ledges, making it difficult for livestock to move about.

In the climax plant community, about 80 percent of the total annual production consists of tall and mid grasses. These grasses are decreasers such as little bluestem, big bluestem, switchgrass, plains muhly, leadplant, resinous skullcap, and prairie-clover. The principal increasers are side-oats grama, blue grama, hairy grama, purple three-awn, broom snakeweed, and smooth sumac. Common invaders are annual three-awn, annual brome, and windmillgrass.

If this site is in excellent condition, the average annual yield is 2,500 pounds of air-dry herbage per acre

in years of favorable moisture. The yield is 800 pounds per acre in years of unfavorable moisture.

#### Management of Soils for Windbreaks

Osborne County has no native forests or large areas of woodland. The trees and shrubs in natural stands grow only in narrow strips in the valleys and on bottom lands along the major streams and their tributaries. Few trees grow large enough to be of commercial value, nevertheless, the trees and shrubs help stabilize the banks of streams and provide food and cover for wildlife.

Most of the trees on uplands in the county are in windbreaks. Windbreaks require careful planning and special management, and each one should be shaped to fit its particular area. The trees and shrubs should be selected on the basis of how well they can grow on the different kinds of soils, and how they should be planted in an area that has been cleared of vegetation. The young trees need protection from fire, livestock, insects, rabbits, and rodents; and cultivation is needed to keep out weeds.

A well planned windbreak (fig. 24) provides an effective barrier against wind. It protects field crops, buildings, livestock, orchards, and gardens, and it also provides food and cover for wildlife.

#### Windbreak suitability groups

The soils of Osborne County have been placed in four windbreak suitability groups according to their suitability for trees and shrubs. Each group consists of

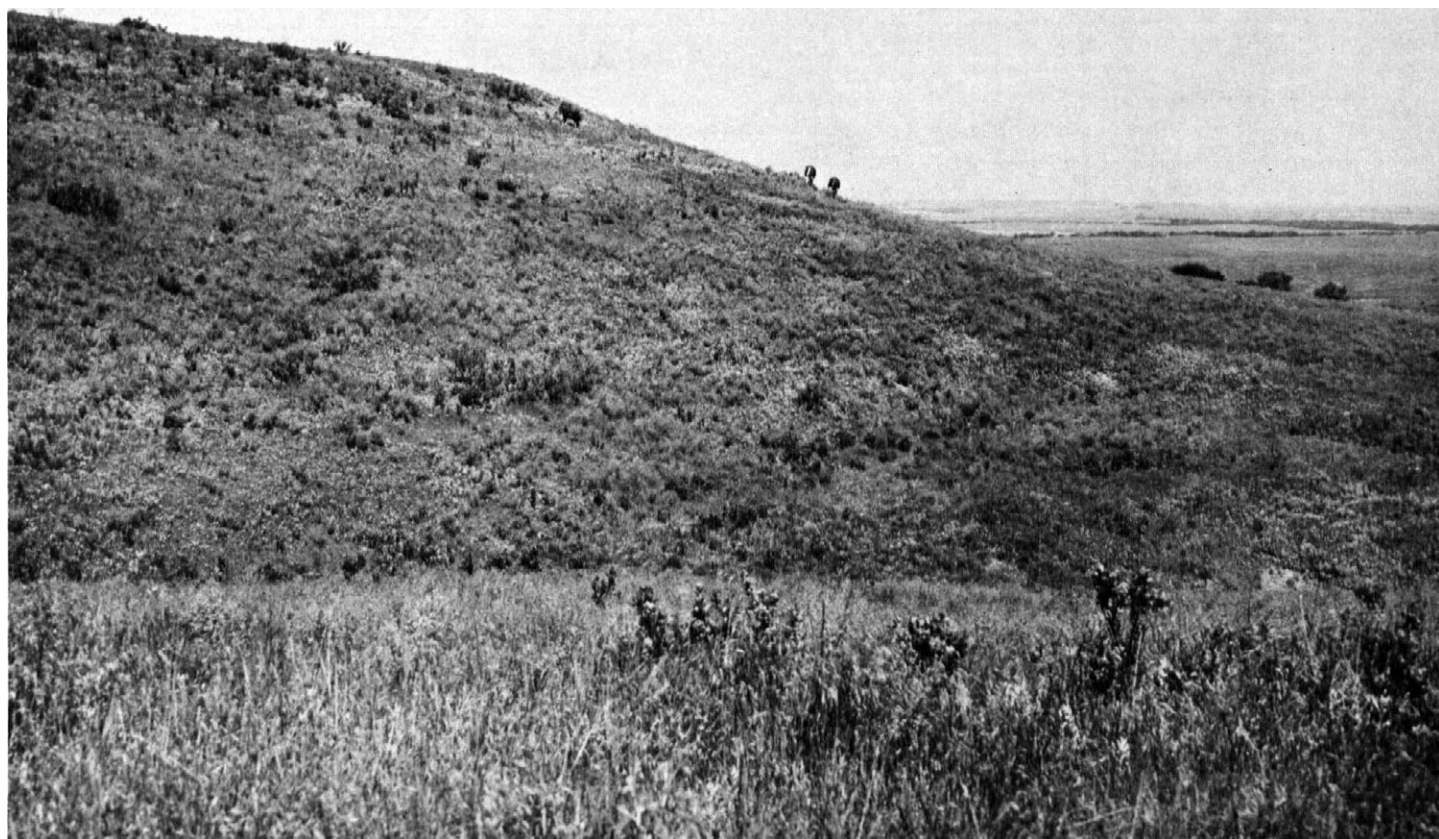


Figure 23.—This area of Shallow Limy range site is in excellent condition. Most of this site is in the Heizer-Brownell complex.



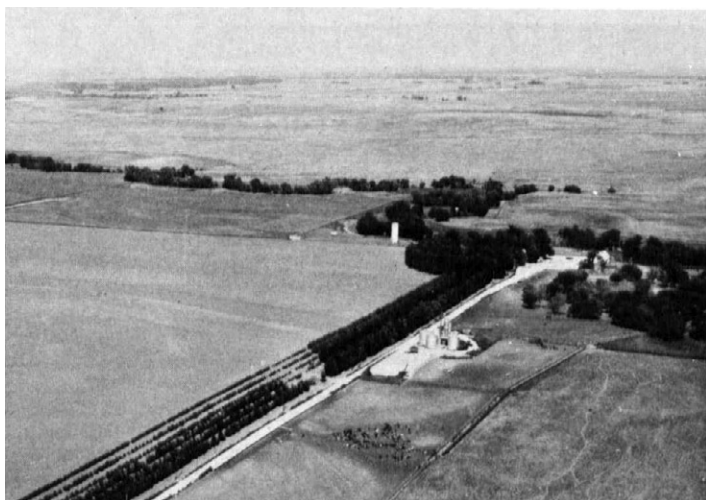


Figure 24.—A young windbreak on Harney silt loam, 1 to 3 per cent slopes, protects a farmstead and small feedlot.

soils that are suited to about the same kinds of trees and shrubs that require similar management, and that have about the same chance of survival and rate of growth. The windbreak suitability group for each soil is listed in the "Guide to Mapping Units."

The soils that have been placed in windbreak suit-

ability group 1 are deep and well drained to moderately well drained. They are loamy and clayey soils that formed in alluvium. Group 2 is made up of deep, well-drained loamy soils on uplands. Group 3 is made up of moderately deep and deep, well-drained limy soils on uplands. The soils in group 4 are moderately deep and shallow and moderately well drained to somewhat excessively drained. They are clayey and sandy.

In table 3 the suitability of the soils in each group is rated for specified trees and shrubs. The ratings for plant vigor are excellent, good, fair, and poor.

*Excellent* indicates that a tree or shrub grows well on the soils in a particular windbreak suitability group. These plants have good leaf color, few, if any, dead branches or die-back in the upper part of their crowns, and no indication of damage by fungi or disease.

*Good* indicates that trees grow moderately well. They have a few dead branches, some die-back in the upper part of their crowns, and slight damage by fungi or insects.

*Fair* indicates that at least half of the trees have a significant number of dead branches in the upper part of their crowns, growth is slow, about one-fourth of the trees are dead, and moderate damage by fungi or insects can be expected for the rest.

*Poor* indicates that less than three-fourths of the trees that are planted will survive, surviving trees will

TABLE 3.—Suitability of the soils for windbreaks

[Estimated height is for trees at an age of 20 years. In some groups, height was not estimated for trees that have poor vigor or do not grow well on the soils in the group]

Trees and shrubs	Windbreak suitability groups							
	Group 1		Group 2		Group 3		Group 4	
	Vigor	Feet	Vigor	Feet	Vigor	Feet	Vigor	Feet
Coniferous trees:								
Eastern redcedar -----	Excellent ---	25	Excellent ---	25	Fair -----	15	Fair -----	15
Western redcedar -----	Good -----	30	Good -----	25	Poor -----		Poor -----	
Ponderosa pine -----	Excellent ---	30	Excellent ---	25	Fair -----	20	Fair -----	15
Austrian pine -----	Excellent ---	30	Excellent ---	35	Fair -----	15	Poor -----	
Tall trees:								
Cottonwood -----	Excellent ---	45	Fair -----	30	Poor -----		( <sup>1</sup> ) -----	
Siberian elm -----	Excellent ---	45	Excellent ---	35	Good -----	30	Fair -----	20
Medium trees:								
Green ash -----	Excellent ---	35	Excellent ---	25	Fair -----	15	Poor -----	
Hackberry -----	Excellent ---	35	Excellent ---	25	Good -----	20	Fair -----	15
Bur oak -----	Excellent ---	30	Excellent ---	20	Fair -----	15	Poor -----	
Black walnut -----	Excellent ---	30	Good -----	25	Poor -----		Poor -----	
Honeylocust -----	Good -----	30	Excellent ---	25	Fair -----	20	( <sup>1</sup> ) -----	
Short trees:								
Russian-olive -----	Excellent ---	20	Excellent ---	18	Good -----	15	Fair -----	10
Russian mulberry -----	Excellent ---	20	Good -----	15	Fair -----	15	Poor -----	
Osage-orange -----	Excellent ---	20	Excellent ---	18	Fair -----	15	Fair -----	10
Shrubs:								
American plum -----	Excellent ---	8	Excellent ---	8	Good -----	5	Fair -----	5
Tamarisk -----	Excellent ---	10	Good -----	10	Poor -----		( <sup>1</sup> ) -----	
Common lilac -----	Excellent ---	8	Excellent ---	8	Poor -----		( <sup>1</sup> ) -----	
Multiflora rose -----	Good -----	6	Fair -----	6	( <sup>1</sup> ) -----		( <sup>1</sup> ) -----	

<sup>1</sup> Not suitable for the soils in this group.

TABLE 4.—*Potential of soil associations for producing habitat for wildlife*

Soil associations	Kinds of wildlife	Potential for producing—		
		Woody cover	Herbaceous cover	Food
1. Harney-Mento-Brownell.	Openland -----	Excellent -----	Excellent -----	Excellent.
	Woodland -----	Poor -----	Good -----	Good.
	Wetland -----	Good -----	Good -----	Good.
2. Armo-Heizer-Bogue.	Openland -----	Good -----	Excellent -----	Excellent.
	Woodland -----	Poor -----	Good -----	Fair.
	Wetland -----	Poor -----	Good -----	Good.
3. Harney-Nuckolls.	Openland -----	Excellent -----	Excellent -----	Excellent.
	Woodland -----	Fair -----	Good -----	Good.
	Wetland -----	Good -----	Good -----	Good.
4. Hord-Roxbury-McCook.	Openland -----	Excellent -----	Excellent -----	Excellent.
	Woodland -----	Excellent -----	Excellent -----	Excellent.
	Wetland -----	Excellent -----	Excellent -----	Excellent.
5. Harney-Corinth-Nibson.	Openland -----	Fair -----	Good -----	Good.
	Woodland -----	Poor -----	Good -----	Good.
	Wetland -----	Fair -----	Good -----	Good.

have severe die-back, and severe damage by fungi and insects can be expected.

### Use of Soils for Fish and Wildlife Habitat<sup>5</sup>

The potential of each soil association in Osborne County for producing food and cover for several kinds of wildlife is rated in table 4. The section "General Soil Map" provides information about the soils in each association and the detailed soil map at the back of this survey shows the location of each association.

In table 4 the kinds of wildlife have been placed in three classes: openland, woodland, and wetland.

Openland wildlife includes animals that inhabit croplands, pastures, meadows, and odd fields of herbaceous vegetation. Pheasant, quail, meadowlarks, cottontail rabbits, coyotes, and badgers live in openland areas. Pheasant can reach a density of one bird for each 6 acres on the Harney-Mento-Brownell and Harney-Corinth-Nibson associations. The bobwhite quail can reach a density of one bird for each 5 acres on the Hord-Roxbury-McCook association.

Woodland wildlife includes animals that inhabit areas of trees and shrubs and need a woody plant cover mixed with other types of cover. White-tailed deer, squirrel, raccoon, and thrushes live in such areas.

Wetland wildlife includes animals that inhabit the wet areas near ponds, marshes, rivers, streams, and swamps. Ducks, shore birds, beaver, mink, and muskrat live in wetland areas.

The proper distribution of plant cover, water, and food is essential for many kinds of wildlife. The soils of Osborne County provide a habitat that is suited to many kinds of animals. Alluvial soils, for example, produce a habitat that is suited to raccoon, fox, squirrel, mink, muskrat, beaver, opossum, and deer and to orioles, thrushes, cardinals, and other songbirds.

Low-growing shrubs, such as plum, sumac, and buckbrush, and the taller growing cedar, honeylocust, osage-orange, and Russian-olive, in gullies and draws provide cover for wildlife and help in controlling erosion. In some places, this woody plant cover is the only cover that is available to quail, deer, rabbits, and doves; without these islands of cover, these kinds of wildlife would vanish from the county.

Ponds are beneficial to waterfowl and fish. In choosing a site for a pond, the soils should be checked for their capability to retain a water supply. Deer and mourning doves are in all soil associations in Osborne County. They depend on farm ponds or streams as a source of water.

Plant food and cover for many desirable kinds of wildlife is produced on the Armo-Heizer-Bogue and Harney-Nuckolls associations. Plants that are suited to these areas vary with soil types.

Technical assistance in wildlife planning is available from the local office of the Soil Conservation Service. Additional assistance or information can be obtained from the Kansas Forestry, Fish and Game Commission, the Bureau of Sport Fisheries and Wildlife, and the Cooperative Extension Service.

### Use of Soils for Recreation Facilities<sup>6</sup>

The potential for recreation enterprises in Osborne County varies with the type of activity. It is greatest for developing picnic areas, camp sites, and small bodies of water for fishing. Even though the Glen Elder and Wilson Reservoirs are within a half-hour drive from the city of Osborne, many people prefer to fish, picnic, and camp near bodies of water that are too small to be used by water skiers and big power boats (fig. 25).

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In

<sup>5</sup> By JACK W. WALSTROM, biologist, Soil Conservation Service.

<sup>6</sup> By JACK W. WALSTROM, biologist, Soil Conservation Service.

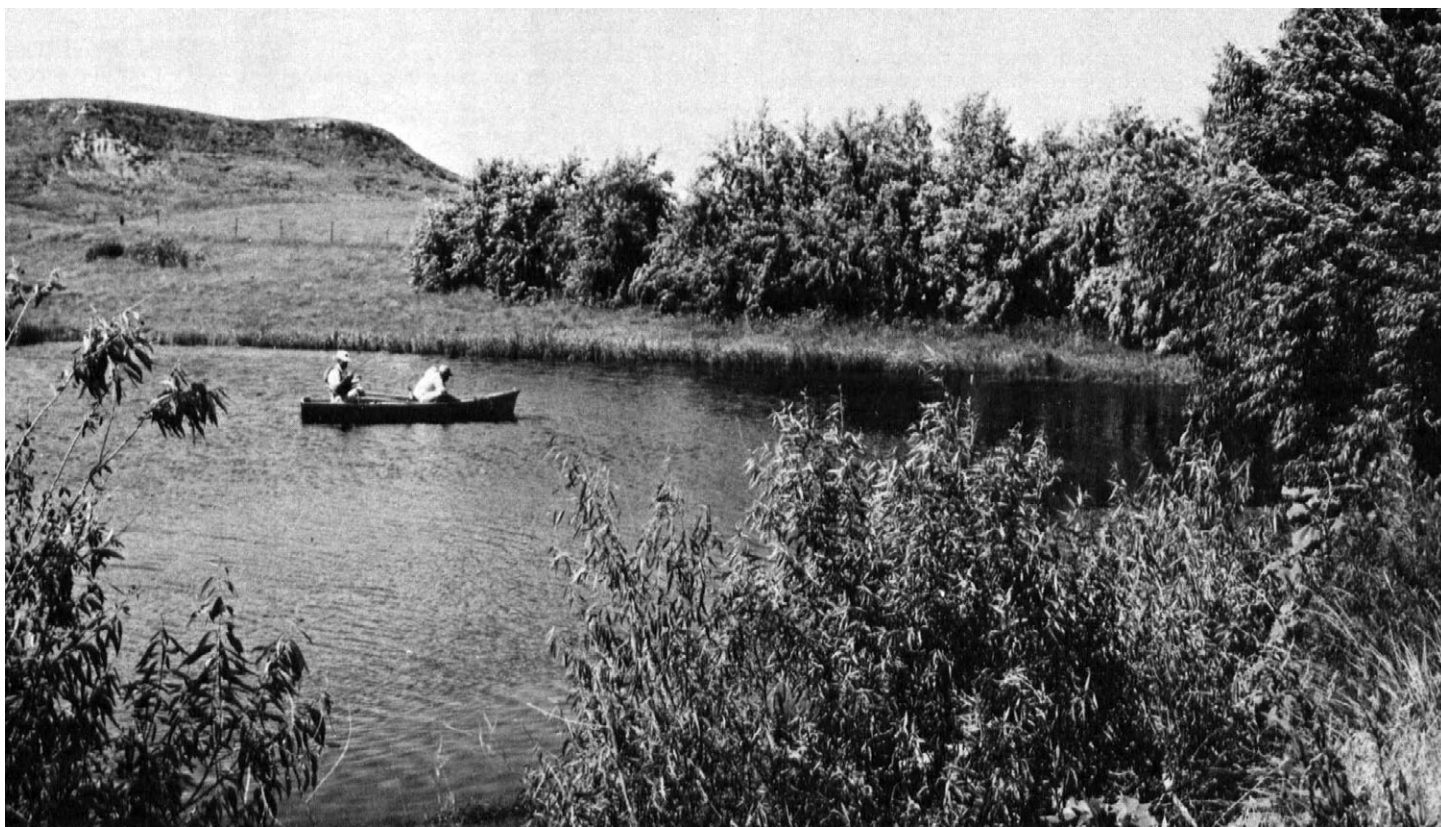


Figure 25.—Farm pond used for fishing and as a picnic area.

table 5 the soils of Osborne County are rated according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails.

In table 5 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these, is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, a surface free of rocks and coarse fragments, and are not subject to flooding during periods of heavy use; their surface is firm after rain but not dusty when dry.

Picnic areas are attractive natural or landscaped tracts that carry heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry, are not subject to flooding during the season of use, and do not have slopes or stones that can greatly increase the cost of leveling or of building access roads.

Playgrounds are areas used intensively for baseball,

football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops. They have good drainage and are not subject to flooding during periods of heavy use. Their surface is firm after rain but not dusty when dry. If grading and leveling are required, depth to rock is important.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

For information about the suitability of soils in recreation areas for use as septic tank absorption fields or sewage lagoons, see table 8.

### Engineering Uses of Soils<sup>7</sup>

This section is useful to planning commissions, town and city managers, land developers, engineers, contractors, farmers, and others who need information about soils used as structural material or as foundation on which structures are built.

Among properties of soils highly important in engineering are permeability, strength, shrink-swell poten-

<sup>7</sup> FRANKLIN C. KINSEY and GLEN CREAGER, JR., civil engineers, Soil Conservation Service, helped prepare this section.

TABLE 5.—*Recreational development*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series as indicated in the first column of this table]

Soil series and map symbols	Degree and kind of soil limitations for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Alluvial land: Aa -----	Severe: subject to flooding.	Moderate: subject to flooding.	Moderate: subject to flooding.	Slight if slope is less than 15 percent: subject to flooding. Severe if slope is more than 25 percent.
Ab -----	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Slight.
*Armo: Ar, As, Ax ----- For Bogue part of Ax, see Bogue series.	Slight if slope is less than 15 percent. Severe if slope is more than 15 percent.	Slight if slope is less than 15 percent. Severe if slope is more than 15 percent.	Moderate if slope is 2 to 6 percent. Severe if slope is more than 6 percent.	Slight.
Bogue: Bo -----	Severe: very slow permeability; clay surface layer.	Severe: clay surface layer.	Severe if slope is more than 6 percent: clay surface layer.	Severe: clay surface layer.
*Brownell: Bw ----- For Wakeen part, see Wakeen series.	Moderate if slope is 8 to 15 percent: rockiness. Severe if slope is more than 15 percent.	Moderate if slope is 8 to 15 percent: rockiness. Severe if slope is more than 15 percent.	Moderate if slope is less than 6 percent: bedrock at a depth of 2 to 3 feet. Severe if slope is more than 6 percent.	Slight to moderate if slope is more than 15 percent.
Corinth: Co -----	Moderate: moderately slow permeability; silty clay loam surface layer.	Slight -----	Moderate: silty clay loam surface layer; moderately slow permeability.	Moderate: silty clay loam surface layer.
Cr -----	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: slope; silty clay loam surface layer.	Severe: slope -----	Moderate: silty clay loam surface layer.
Detroit: De -----	Moderate: slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
*Harney: Ha, Hb, Hc, Hn ----- For Nuckolls part of Hn, see Nuckolls series.	Slight to moderate: moderately slow permeability.	Slight if slope is less than 8 percent. Moderate if slope is more than 8 percent.	Slight to moderate if slope is less than 2 percent: moderately slow permeability. Moderate if slope is more than 2 percent.	Slight.
Hd -----	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
He, Hm ----- For Mento part, see Mento series.	Slight to moderate: moderately slow permeability.	Slight -----	Slight if slope is less than 2 percent. Moderate if slope is more than 2 percent.	Slight.
*Heizer: Hx ----- For Brownell part, see Brownell series.	Severe: slope; rockiness.	Severe: slope; rockiness.	Severe: slope; rockiness; bedrock at a depth of 12 to 18 inches.	Moderate if slope is less than 25 percent: rockiness. Severe if slope is more than 25 percent.
Hord: Hz -----	Slight -----	Slight -----	Slight -----	Slight.

TABLE 5.—*Recreational development*—Continued

Soil series and map symbols	Degree and kind of soil limitations for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Inavale: In -----	Severe: loamy fine sand surface layer; spots of loose sand; slope.	Severe: loamy fine sand surface layer; spots of loose sand; slope.	Severe: loamy fine sand surface layer; spots of loose sand; slope.	Moderate to severe: loamy fine sand surface layer; spots of loose sand.
McCook: Ma -----	Slight -----	Slight -----	Slight -----	Slight.
Mento ----- Mapped only in complexes with Harney soils and Wakeen soils.	Moderate: slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate if slope is more than 2 percent: silty clay loam surface layer; slow permeability.	Moderate: silty clay loam surface layer.
*Munjor: Mc ----- For McCook part, see McCook series.	Moderate to severe: subject to flooding.	Moderate: subject to flooding.	Slight to moderate: subject to flooding.	Slight.
New Cambria: Nc, Nd --	Severe: silty clay surface layer; subject to flooding.	Severe: silty clay surface layer; subject to flooding.	Severe: silty clay surface layer.	Severe: silty clay surface layer.
Nibson: Nx -----	Moderate if slope is less than 15 percent: stoniness. Severe if slope is more than 15 percent.	Moderate if slope is less than 15 percent: stoniness. Severe if slope is more than 15 percent.	Severe: slope; stoniness.	Slight to moderate: slope; stoniness.
Nuckolls ----- Mapped only with Harney soils.	Slight -----	Slight -----	Moderate if slope is less than 6 percent. Severe if slope is more than 6 percent.	Slight.
Roxbury: Ro, Rp, Rr -----	Slight to moderate: subject to flooding.	Slight -----	Slight if slope is less than 2 percent. Moderate if slope is more than 2 percent.	Slight.
Roxbury soil in Tr ---	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Slight.
*Timken: Tb, Tm ----- For Bogue part of Tb, see Bogue series. Shale outcrop in Tm is too variable to rate.	Severe: slope; clay surface layer.	Severe: slope; clay surface layer.	Severe: slope; clay surface layer.	Severe: clay surface layer.
*Tobin: Tr ----- For Roxbury part, see Roxbury series.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Slight.
*Wakeen: Wm ----- For Mento part, see Mento series.	Slight if slope is less than 8 percent. Moderate if slope is more than 8 percent.	Slight if slope is less than 8 percent. Moderate if slope is more than 8 percent.	Moderate if slope is less than 6 percent. Severe if slope is more than 6 percent.	Slight.

tial, grain size, plasticity, and reaction. Also important are slope and depth to bedrock. These properties, in various degrees and combinations, affect construction and maintenance of roads, pipelines, foundations for small buildings, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.



5. Correlate performance of structures already built with properties of the soils on which they are built to help predict performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables. Table 6 shows the results of engineering laboratory tests on soil samples. Table 7 shows estimated soil properties significant to engineering. Table 8 gives interpretations for various engineering uses.

This information, along with the soil map and data in other parts of this publication, can be used to make interpretations in addition to those given in tables 7 and 8, and it also can be used to make useful maps.

This information, however, does not eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than 5 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil can include small areas of other kinds of soil that have strongly contrasting properties and different suitability or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists. The Glossary defines many of these terms.

### **Engineering classification systems**

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (2, 8, 10), used by SCS engineers, the Department of Defense, and others, and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO) (1).

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt, that is not mapped in Osborne County.

In the Unified system a fine-grained soil is one in which more than half of the material passed through a No. 200 sieve. The sieve has openings 0.074 millimeter in size.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7,

A-7-5, and A-7-6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in table 6; the estimated classification, without group index numbers, is given in table 7 for all soils mapped in the survey area.

In the AASHTO system, the soil material is in two general groups: (1) granular material in which 35 percent or less passes a No. 200 sieve, and (2) silt-clay material in which more than 35 percent passes a No. 200 sieve. The silty part of the silt-clay material has a plasticity index of 10 or less, and the clayey material has a plasticity index of more than 10.

### **Engineering test data**

Table 6 contains engineering test data for some of the major soil series in Osborne County. The tests were made to help evaluate the soils for engineering purposes. The engineering classifications are based on data obtained by mechanical analyses and by tests to determine liquid limit and plastic limit. The mechanical analyses were made by combined sieve and hydrometer methods.

Moisture-density data are important in earthwork. If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Mechanical analyses show the percentages, by weight, of soil particles that pass through sieves of specified sizes. Sand and other coarser materials do not pass through the No. 200 sieve, but silt and clay will pass through. Percentage fractions smaller than openings in the No. 200 sieve were determined by the hydrometer method, rather than the pipette method used by most soil scientists in determining the amount of clay in the soil samples.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from semisolid to plastic. If the moisture content is further increased, the material changes from plastic to liquid. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic; and the liquid limit, from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Liquid limit and plasticity index in table 7 are based on tests of soil samples.

### **Estimated engineering properties**

Several estimated soil properties significant in engineering are given in table 7. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The

TABLE 6.—*Engineering*

[Tests made by the State Highway Commission of Kansas in accordance with standard

Soil name and location	Parent material	Report number S-70-Kans.	Depth	Moisture-density data <sup>1</sup>	
				Maximum dry density	Optimum moisture
			<i>In</i>	<i>Lb/cu ft</i>	<i>Pct</i>
Harney silt loam: 2,000 feet west and 350 feet north of the south-east corner of sec. 20, T. 7 S., R. 13 W. (Modal)	Loess.	71-8-1	0-10	103	19
		71-8-4	18-26	98	22
		71-8-6	30-46	99	22
		71-8-7	46-72	100	21
Hord silt loam: 2,200 feet west and 1,500 feet south of the northeast corner of sec. 26, T. 7 S., R. 12 W. (Modal)	Silty alluvium.	71-5-1	0-15	102	18
		71-5-2	15-26	100	20
		71-5-4	32-42	106	17
McCook silt loam: 2,400 feet west and 2,350 feet north of the southeast corner of sec. 23, T. 7 S., R. 12 W. (Modal)	Silty alluvium.	71-4-1	0-12	106	17
		71-4-3	16-22	108	17
		71-4-4	22-32	104	19
		71-4-5	32-47	110	16
Mento silty clay loam: 400 feet south and 450 feet west of the north-east corner of sec. 33, T. 7 S., R. 15 W. (Modal)	Loess over unweathered chalk.	71-6-1	0-6	103	20
		71-6-2	6-12	96	23
		71-6-3	12-20	100	20
		71-6-5	32-48	100	21
Roxbury silt loam: 1,400 feet south and 800 feet west of the north-east corner of sec. 10, T. 8 S., R. 14 W. (Modal)	Alluvium.	71-7-1	0-18	98	22
		71-7-2	18-30	99	22
		71-7-3	30-42	90	26
Timken clay: 1,200 feet east and 2,000 feet south of the northwest corner of sec. 16, T. 9 S., R. 12 W. (Modal)	Clay shale.	71-3-1	0-6	93	24
		71-3-2	6-12	94	24
		71-3-4	18-48	94	23

<sup>1</sup> Based on AASHTO Designation T99-61, Method A, with the following variations: (1) all material is oven-dried at 230° F., (2) all material is crushed after drying, and (3) no time is allowed for dispersion of moisture after mixing with the soil material.

<sup>2</sup> Mechanical analyses according to the AASHTO Designation T88-57 with the following variations: (1) all material is oven-dried at 230° F and crushed, (2) the sample is not soaked prior to dispersion, (3) sodium silicate is used as the dispersing agent, and (4) dispersing time, in minutes, is established by dividing the plasticity index value by 2. The maximum dispersing time is 15 minutes, and the minimum time is 1 minute. Results by this procedure frequently differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material

*test data*

procedures of the American Association of State Highway and Transportation Officials (AASHTO)]

Mechanical analysis <sup>2</sup>							Liquid limit	Plasticity index	Classification	
Percentage less than 3 inches passing sieve—			Percentage smaller than—						AASHTO <sup>3</sup>	Unified <sup>4</sup>
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm				
							<i>Pct</i>			
100	100	96	83	50	27	20	33	11	A-6(8)	ML-CL
100	100	98	93	69	45	38	50	26	A-7-6(16)	CL
100	100	98	92	66	36	28	41	17	A-7-6(11)	ML-CL
100	100	98	91	61	31	20	36	12	A-6(9)	ML-CL
100	100	98	92	59	34	27	35	15	A-6(10)	CL
100	100	98	93	64	42	37	44	21	A-7-6(13)	CL
100	100	98	90	54	24	19	33	11	A-6(8)	ML-CL
100	99	86	75	46	21	15	31	8	A-4(8)	ML-CL
100	100	93	83	42	23	17	31	9	A-4(8)	ML-CL
100	100	98	92	64	36	28	36	14	A-6(10)	CL
100	99	82	72	36	18	14	27	7	A-4(8)	ML-CL
100	100	97	92	55	28	22	32	11	A-6(8)	CL
100	100	98	94	71	48	43	52	29	A-7-6(18)	CH
100	100	99	94	70	42	35	49	28	A-7-6(17)	CL
100	100	98	91	63	40	36	43	25	A-7-6(15)	CL
100	100	97	74	61	38	30	40	16	A-6(10)	ML-CL
100	100	93	87	64	40	30	39	15	A-6(10)	ML-CL
100	100	97	92	72	45	35	46	16	A-7-5(12)	ML
100	99	96	95	93	83	69	71	44	A-7-6(20)	CH
100	100	99	99	98	87	74	76	48	A-7-6(20)	CH
100	100	98	98	96	85	71	68	38	A-7-5(20)	CH

is analyzed by the hydrometer method, and various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

<sup>2</sup> Based on AASHTO Designation M 145-49 (1).

<sup>4</sup> The SCS and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within two points from A-line are to be given a borderline classification.

TABLE 7.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The as indicated in the first column of this table. Absence of data indicates that the soil is too variable to be

Soil series and map symbols	Depth to bedrock	Depth from surface	USDA texture	Classification	
				Unified	AASHTO
	<i>Feet</i>	<i>Inches</i>			
Alluvial land: Aa, Ab. Too variable to estimate.					
*Armo: Ar, As, Ax ----- For Bogue part of Ax, see Bogue series.	>5	0-11 11-60	Silt loam ----- Silty clay loam -----	CL or ML-CL CL	A-6 A-6
Bogue: Bo -----	1-2-3	0-33 33-47	Clay ----- Clay shale -----	CH CH	A-7 A-7
*Brownell: Bw ----- For Wakeen part, see Wakeen series.	2-3	0-8 8-15 15-27	Gravelly loam ----- Very gravelly loam ----- Channery loam -----	SM or SC GM or GC GM or GC GW-GM or GW-GC	A-2 A-2 A-2
		27-30	Limestone.		
Corinth: Co, Cr -----	1-2-3	0-7 7-26 26-48	Silty clay loam ----- Silty clay ----- Silty clay shale -----	CH CH CL or CH	A-7 A-7 A-7
Detroit: De -----	>5	0-12 12-46 46-60	Silty clay loam ----- Silty clay ----- Silty clay loam -----	CL CH CL	A-6 or A-7 A-7 A-7
*Harney silt loam: Ha, Hb, Hc, He, Hm, Hn ----- For Mento parts of He and Hm, and Nuckolls part of Hn, see those series. Hd -----	>5	0-10 10-30 30-72	Silt loam ----- Silty clay loam ----- Silt loam -----	ML-CL or CL CL or CH ML-CL	A-6 or A-4 A-6 or A-7 A-6 or A-7
		0-30 30-60	Silty clay loam ----- Silt loam -----	CL or CH ML-CL	A-6 or A-7 A-6 or A-7
*Heizer: Hx ----- For Brownell part, see Brownell series.	1-1½	0-9 9-16	Gravelly loam ----- Channery loam -----	SM or SC GM or GC GW-GM or GW-GC	A-1 or A-2 A-1
		16-24	Limestone.		
Hord: Hz -----	>5	0-60	Silt loam -----	ML-CL or CL	A-4 or A-6
Inavale: In -----	>5	0-6 6-50	Loamy fine sand ----- Fine sand -----	SM SP-SM	A-2 A-3
McCook: Ma -----	>5	0-32 32-47 47-63	Coarse silt loam ----- Very fine sandy loam ----- Loamy sand -----	ML-CL ML or ML-CL SM	A-4 or A-6 A-4 or A-6 A-4
Mento ----- Mapped only in complexes with Harney and Wakeen soils.	3½-5	0-6 6-20 20-48 48-60	Silty clay loam ----- Heavy silty clay loam ----- Silty clay loam ----- Soft limestone.	ML or CL CH or CL CL	A-4 or A-6 A-7 A-4 or A-6
*Munjor: Mc ----- For McCook part, see McCook series.	>5	0-28 28-40	Sandy loam ----- Fine sand -----	SM or SM-SC SM or SP-SM	A-2 A-2 or A-3
New Cambria: Nc, Nd -----	>5	0-40 40-60	Silty clay ----- Silty clay loam -----	CH CH	A-7 A-7
Nibson: Nx -----	1-1½	0-8 8-19 19-24	Silt loam ----- Silty clay loam ----- Limestone interbedded with shale.	ML or CL ML-CL or CL	A-4 or A-6 A-6 or A-7
Nuckolls ----- Mapped only with Harney soils.	>5	0-11 11-35 35-60	Silt loam ----- Silty clay loam ----- Silt loam -----	ML or ML-CL CL or ML ML or ML-CL	A-4 A-6 or A-4 A-4

*significant in engineering*

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series rated or that no estimate was made. The symbol > means greater than; the symbol < means less than]

Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
				<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH</i>	
95-100	90-100	85-100	70-95	0.6-2.0	0.20-0.23	7.4-7.8	Low.
85-100	80-100	75-95	70-95	0.6-2.0	0.19-0.21	7.9-8.1	Low.
100	100	95-100	90-100	<0.06	0.11-0.13	6.4-7.0	Very high.
100	100	95-100	90-100	<0.06	0.05	3.5-5.8	Very high.
<sup>a</sup> 50-80	40-50	30-45	20-35	0.6-2.0	0.14-0.18	8.0-8.5	Low.
<sup>a</sup> 40-50	30-45	20-40	13-30	0.6-2.0	0.10-0.14	8.0-8.5	Low.
<sup>a</sup> 20-40	15-35	10-30	8-25	0.6-2.0	0.06-0.10	8.5-9.0	Low.
100	100	90-100	80-95	0.2-0.60	0.20-0.22	7.4-7.8	Moderate.
100	100	90-100	80-95	0.2-0.60	0.13-0.15	7.9-8.4	Moderate.
100	100	90-100	80-95	<0.06	0.05	8.5-9.0	Moderate.
100	100	95-100	90-100	0.2-0.6	0.21-0.23	6.3-6.5	Moderate.
100	100	95-100	90-100	0.06-0.2	0.11-0.13	6.6-8.0	High.
100	95-100	90-100	85-95	0.2-0.6	0.18-0.20	7.9-8.4	Moderate.
100	100	95-100	80-100	0.6-2.0	0.22-0.24	6.6-7.0	Low to moderate.
100	100	95-100	80-100	0.2-0.6	0.18-0.20	7.3-7.7	Moderate to high.
100	100	95-100	80-100	0.2-0.6	0.20-0.22	7.8-8.2	Low.
100	100	95-100	80-95	0.2-0.6	0.19-0.21	7.3-7.7	Moderate to high.
100	100	95-100	70-90	0.2-0.6	0.20-0.22	7.8-8.2	Low.
50-60	40-50	30-40	20-35	0.6-2.0	0.14-0.18	8.0-8.4	Low.
20-40	15-35	10-30	8-25	0.6-2.0	0.06-0.10	8.0-8.4	Low.
100	100	90-100	85-100	0.6-2.0	0.21-0.23	6.4-8.0	Moderate.
90-100	85-100	50-75	20-35	6.0-20	0.10-0.12	7.8-8.4	Low.
90-100	85-100	50-70	5-10	6.0-20	0.06-0.08	8.2-8.5	Low.
100	100	90-100	85-100	0.6-2.0	0.19-0.21	7.4-7.8	Low.
100	100	85-100	70-90	0.6-2.0	0.15-0.17	7.9-8.4	Low.
100	100	50-75	15-30	2.0-6.0	0.08-0.10	7.9-8.4	Low.
100	95-100	90-100	85-100	0.2-0.6	0.21-0.23	7.0-8.0	Moderate.
100	95-100	90-100	85-100	0.2-0.6	0.16-0.18	7.0-8.0	High.
100	95-100	90-100	85-100	0.2-0.6	0.16-0.18	7.0-8.0	Moderate.
100	95-100	60-70	20-35	2.0-6.0	0.13-0.15	7.8-8.4	Low.
95-100	90-95	55-70	5-20	2.0-6.0	0.06-0.08	7.9-8.4	Low.
100	100	95-100	90-100	0.06-0.2	0.12-0.14	7.0-8.0	High.
100	100	95-100	85-95	0.06-0.2	0.18-0.20	7.9-8.4	High.
75-100	70-95	65-95	60-90	0.6-2.0	0.20-0.22	7.0-8.0	Low.
75-95	65-95	60-90	55-90	0.6-2.0	0.18-0.20	7.9-8.4	Low.
100	100	90-100	70-90	0.6-2.0	0.22-0.24	6.7-7.0	Low.
100	100	95-100	85-95	0.6-2.0	0.18-0.20	7.4-8.0	Low to moderate.
100	95-100	90-100	70-90	0.6-2.0	0.20-0.22	8.0-8.4	Low.



TABLE 7.—*Estimated soil properties*

Soil series and map symbols	Depth to bedrock	Depth from surface	USDA texture	Classification	
				Unified	AASHTO
	<i>Feet</i>	<i>Inches</i>			
*Roxbury: Ro, Rp, Rr, Tr ----- For Tobin part of Tr, see Tobin series.	>5	0-72	Silt loam -----	ML-CL or CL	A-6 or A-4
*Timken: Tb, Tm ----- For Bogue part of Tb, see Bogue series. Shale outcrop in Tm is too variable to estimate.	<sup>1</sup> 1-1½	0-16 16-60	Clay ----- Clay shale -----	CH CH	A-7 A-7
*Tobin: Tr ----- For Roxbury part, see Roxbury series.	>5	0-20 20-45 45-60	Silt loam ----- Silty clay loam ----- Silt loam -----	ML-CL or CL CL ML-CL or CL	A-6 or A-4 A-6 or A-7 A-6 or A-4
*Wakeen: Wm ----- For Mento part, see Mento series.	2-3	0-10 10-34 34-48	Silt loam ----- Silty clay loam ----- Soft limestone.	ML-CL or CL ML-CL or CL	A-6 or A-7 A-6 or A-7

<sup>1</sup> These soils are underlain by soft shale.

estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties.

Alluvial land, loamy, Alluvial land, mixed, and Timken-Shale outcrop complex have variable properties and are not included in table 7.

Alluvial land, loamy, Alluvial land, mixed, Munjor-McCook loams, New Cambria silty clay, frequently flooded, Roxbury silt loam, channeled, and Tobin and Roxbury silt loams are subject to occasional flooding.

Depth to the water table is not given in table 7. The water table fluctuates throughout the flood plain of the North and South Forks of the Solomon River. Depth to the water table ranges from 10 to 50 feet.

Soil texture is described in table 7 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in the soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used are defined in the Glossary of this soil survey.

Following are explanations of some of the columns in table 7.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 7 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in

the soil at field capacity and the amount at wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to the maintenance of structures built in, on, or with material having this rating.

#### **Engineering interpretations of soils**

The estimated interpretations in table 8 are based on the engineering properties of soils shown in table 7, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Osborne County. In table 8, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for highway location, ponds and reservoirs, embankments, terraces and diversions, and irrigation. For these particular uses, table 8 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means soil properties generally are favorable for the rated use or, in other words, the limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties are so

significant in engineering—Continued

Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
100	100	90-100	85-100	<i>Inches per hour</i> 0.6-2.0	<i>Inches per inch of soil</i> 0.22-0.24	<i>pH</i> 7.5-8.0	Low to moderate.
100	100	95-100	90-100	0.06-0.2	0.11-0.13	5.6-6.5	Very high.
100	100	95-100	90-100	<0.06	0.05	3.5-5.5	Very high.
100	100	90-100	85-95	0.6-2.0	0.22-0.24	6.6-7.3	Low to moderate.
100	100	95-100	95-100	0.6-2.0	0.18-0.20	7.5-8.0	Moderate.
100	100	90-100	85-95	0.6-2.0	0.20-0.22	7.9-8.4	Low to moderate.
100	100	85-100	75-95	0.6-2.0	0.20-0.22	7.9-8.4	Low to moderate.
100	95-100	85-100	75-95	0.6-2.0	0.17-0.19	7.9-8.4	Low to moderate.

<sup>a</sup> Estimate of fragments larger than 3 inches in diameter is 5 to 30 percent in the 0 to 8 and 8 to 15 inch layers and 10 to 40 percent in the 15 to 27 inch layer.

unfavorable and so difficult to correct or overcome that major soil reclamation and special designs are required.

Soil suitability is rated by the terms *good*, *fair*, and *poor*, which have meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 8.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects layout and construction and also risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage, within a depth of 2 to 5 feet, long enough for bacteria to decompose the solids. A lagoon has a nearly level floor; its sides, or embankments, are of soil material compacted to medium density, and the pond is protected from flooding. Properties that affect the pond floor are permeability, organic matter, and slope, and if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amounts of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and

cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or absence of a high water table.

Foundations for low buildings, as rated in table 8, are for buildings that are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for low buildings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as in preparing a seedbed; natural fertility of the material or plant response when fertilizer is added to the soil; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments affect suitability, and also considered in the ratings is damage that can result at the area from which topsoil is taken.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Road fill is soil material used in embankments for roads. The suitability ratings reflect (1) the predicted

TABLE 8.—*Interpretations of engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The indicated in the first

Soil series and map symbols	Degree and kind of soil limitation for—					Suitability of the soil as a source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary <sup>1</sup> landfill	Cover material for sanitary landfill	Topsoil
Alluvial land: Aa, Ab. Properties are too variable to estimate.							
*Armo: Ar, As, Ax ----- For Bogue part of Ax, see Bogue series.	Moderate: moderate permeability; slope.	Moderate to severe: moderate permeability; possible pockets of gravel; slope.	Moderate: possible pockets of gravel.	Moderate: slope of 3 to 20 percent.	Slight to moderate (trench): slope of 3 to 20 percent; texture. Moderate where slope is less than 15 percent (area): severe where slope is more than 15 percent.	Fair: slope; texture.	Fair: slope of 3 to 20 percent; high pH.
Bogue: Bo -----	Severe: very slow permeability.	Moderate to severe: slope of 3 to 30 percent; shale at a depth of less than 40 inches.	Moderate to severe: shale at a depth of less than 40 inches; slope.	Severe: very high shrink-swell potential; subject to slides; high compressibility.	Severe (trench): clay texture; shale depth of less than 40 inches. Moderate (area): slope.	Poor: clay texture.	Poor: clay texture.
*Brownell: Bw ----- For Wakeen part, see Wakeen series.	Severe: bedrock at a depth of less than 40 inches.	Severe: bedrock at a depth of less than 40 inches.	Severe: limestone at a depth of less than 40 inches.	Moderate to severe: bedrock at a depth of 2 to 3 feet; slope of 7 to 30 percent.	Severe (trench): bedrock at a depth of less than 40 inches; rockiness. Moderate to severe (area): slope.	Poor: coarse fragments; surface stones.	Poor: coarse fragments.
Corinth: Co, Cr -----	Severe: moderately slow permeability; shale at a depth of less than 40 inches.	Moderate to severe: slope of 3 to 15 percent; soft shale at a depth of less than 40 inches.	Moderate: soft shale at a depth of less than 40 inches.	Moderate: moderate shrink-swell potential; high compressibility.	Severe (trench): shale is at a depth of less than 40 inches. Moderate (area): slope.	Poor: texture.	Poor: moderately fine texture; high pH; clayey subsoil.
Detroit: De -----	Severe: slow permeability; possible flooding.	Severe: possible flooding.	Moderate: possible flooding.	Moderate to severe: moderate to high shrink-swell potential; possible flooding.	Moderate to severe (trench): texture; possible flooding. Moderate (area): possible flooding.	Fair: texture.	Fair: moderately fine textured.

*properties of the soils*

soils in such mapping units have different properties and limitations, and for this reason it is necessary to refer to other series as column of this table]

Suitability of the soil as a source of—continued			Soil features affecting				
Sand and gravel	Road subgrade <sup>2</sup>	Road fill <sup>3</sup>	Highway location <sup>2</sup>	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions and waterways	Irrigation
Poor: possible pockets of limestone gravel.	Poor: low soil support.	Fair: fair shear strength.	Slope of 3 to 20 percent; moderate erodibility.	High seepage loss.	Fair to good stability; fair to good compaction.	Slope of 3 to 20 percent; possible gravel pockets; high pH.	Slopes of 3 to 20 percent; possible gravel pockets.
Unsuited -----	Poor: high plasticity.	Poor: poor shear strength.	Poor foundation material; slope of 3 to 30 percent; shale at a depth of less than 40 inches.	Very slow permeability.	Fair to poor stability; fair to poor compaction; very high shrink-swell potential; high compressibility.	Slope of 3 to 30 percent; clay shale at a depth of less than 40 inches.	Generally not applicable.
Source of crushed rock.	Good to a depth of 15 inches, poor below a depth of 15 inches; 3 to 6 inches of rock fragments.	Good -----	Slope of 3 to 15 percent; bedrock at a depth of less than 40 inches.	High seepage loss.	Limited borrow material; bedrock at a depth of 2 to 3 feet.	Slope of 7 to 30 percent; bedrock at a depth of 2 to 3 feet.	Generally not applicable.
Unsuited -----	Fair: fair shear strength.	Fair: fair shear strength.	Slope of 3 to 15 percent; shale at a depth of less than 40 inches.	Moderately slow permeability.	Fair stability; fair to poor compaction; moderate shrink-swell potential; high compressibility.	Slope of 3 to 15 percent; soft shale at a depth of 2 to 3 feet; high pH.	Generally not applicable.
Unsuited -----	Poor: high plasticity.	Fair: fair shear strength.	No adverse features.	Slow permeability.	Fair stability; moderate shrink-swell potential; fair shear strength; fair compaction.	No adverse features.	High available water capacity; moderately slow intake rate; nearly level.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of soil limitation for—					Suitability of the soil as a source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary <sup>1</sup> landfill	Cover material for sanitary landfill	Topsoil
<p><b>*Harney:</b> Ha, Hb, Hc, He, Hm, Hn. For Mento parts of He and Hm, and for Nuckolls part of Hn, see those series.</p> <p>Hd -----</p>	<p>Moderate to severe: moderately slow permeability.</p> <p>Moderate to severe: moderately slow permeability.</p>	<p>Slight to moderate: slope of 0 to 8 percent.</p> <p>Moderate: slope of 2 to 7 percent.</p>	<p>Slight -----</p> <p>Slight -----</p>	<p>Moderate to severe: moderate to high shrink-swell potential; medium to high compressibility.</p> <p>Moderate to severe: moderate to high shrink-swell potential; medium to high compressibility.</p>	<p>Slight (trench). Slight (area).</p> <p>Slight (trench). Slight (area).</p>	<p>Fair to good: texture.</p> <p>Fair: texture.</p>	<p>Good -----</p> <p>Fair: moderately fine texture.</p>
<p><b>*Heizer:</b> Hx ----- For Brownell part, see Brownell series.</p>	<p>Severe: bedrock at a depth of less than 20 inches.</p>	<p>Severe: bedrock at a depth of less than 20 inches; slope of 7 to 30 percent.</p>	<p>Severe: bedrock at a depth of less than 20 inches.</p>	<p>Severe: bedrock at a depth of less than 20 inches.</p>	<p>Severe (trench): bedrock at a depth of less than 20 inches; slope. Severe (area): slope.</p>	<p>Poor: coarse fragments; surface stones.</p>	<p>Poor: shallow over limestone; slope of 7 to 30 percent.</p>
<p>Hord: Hz -----</p>	<p>Slight to moderate: moderate permeability.</p>	<p>Moderate: moderate permeability.</p>	<p>Slight -----</p>	<p>Moderate: moderate shrink-swell potential; medium to high compressibility.</p>	<p>Slight (trench). Slight (area).</p>	<p>Good -----</p>	<p>Good -----</p>
<p>Inavale: In -----</p>	<p>Severe: potential seepage into nearby stream.</p>	<p>Severe: permeability; subject to flooding.</p>	<p>Severe: texture.</p>	<p>Severe: flooding.</p>	<p>Severe (trench): permeability. Severe (area): permeability.</p>	<p>Fair: sandy texture.</p>	<p>Poor: sandy texture.</p>
<p>McCook: Ma -----</p>	<p>Severe: possible seepage into nearby stream; subject to flooding.</p>	<p>Moderate to severe: moderate permeability; subject to flooding.</p>	<p>Moderate: sandy substratum; subject to flooding.</p>	<p>Severe: subject to flooding.</p>	<p>Severe (trench): possible seepage into nearby stream; subject to flooding. Severe (area): possible seepage into nearby stream; subject to flooding.</p>	<p>Good -----</p>	<p>Good -----</p>



*properties of the soils—Continued*

Suitability of the soil as a source of—continued			Soil features affecting—				
Sand and gravel	Road subgrade <sup>2</sup>	Road fill <sup>2</sup>	Highway location <sup>2</sup>	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions and waterways	Irrigation
Unsuited -----	Fair: medium plasticity.	Fair: fair shear strength.	Slope of 0 to 8 percent.	Moderately slow permeability.	Fair stability; fair compaction; fair shear strength.	Moderately slow permeability; moderate erodibility.	High available water capacity; moderately slow intake rate; slope of 0 to 8 percent; deep.
Unsuited -----	Fair: medium plasticity.	Fair: fair shear strength.	Slope of 2 to 7 percent.	Moderately slow permeability.	Fair stability; fair compaction; fair shear strength.	Moderate erodibility; silty clay loam surface layer.	High available water capacity; slow to moderately slow intake rate; slope of 2 to 7 percent.
Source of crushed rock.	Poor: 3- to 12-inch fragments of rock.	Fair: poor workability.	Slopes of 7 to 30 percent; bedrock at a depth of less than 20 inches.	High seepage loss; bedrock at a depth of less than 20 inches.	Bedrock at a depth of less than 20 inches; slope of 7 to 30 percent; limited borrow material.	Slope of 7 to 30 percent; bedrock at a depth of less than 20 inches.	Generally not applicable.
Unsuited -----	Fair: fair stability.	Fair: fair shear strength.	No adverse features.	Moderate permeability.	Fair stability; fair shear strength; fair compaction.	No adverse features.	High available water capacity; moderate intake rate; nearly level; deep.
Fair in substratum: poorly graded.	Good -----	Good -----	High erodibility; some areas subject to flooding.	High seepage loss; rapid permeability.	Fair to poor stability; poor resistance to piping; fair to good compaction; high erodibility.	Shallow over sand; very high erodibility.	Generally not applicable.
Unsuited -----	Good -----	Good -----	Moderate erodibility; some areas are subject to flooding.	Moderate permeability; high seepage loss.	Fair stability; fair shear strength; moderate erodibility; good compaction.	No adverse features.	High available water capacity; moderate intake rate; nearly level; deep.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of soil limitation for—					Suitability of the soil as a source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary <sup>1</sup> landfill	Cover material for sanitary landfill	Topsoil
Mento ----- Mapped only in complexes with Harney and Wakeen soils.	Severe: slow permeability; less than 60 inches to bedrock.	Moderate: bedrock at a depth of 40 to 60 inches; slope of 1 to 8 percent.	Moderate: bedrock at a depth of less than 60 inches.	Moderate: moderate shrink-swell potential; medium to high compressibility.	Severe (trench): bedrock at a depth of less than 60 inches. Slight (area).	Fair to poor: texture.	Fair to a depth of 8 inches, poor below; high content of soluble salts.
*Munjor: Mc ----- For McCook part, see McCook series.	Severe: subject to flooding; potential seepage into nearby stream.	Severe: texture; subject to flooding.	Severe: subject to flooding; texture.	Severe: subject to flooding.	Severe (trench): subject to flooding. Severe (area): subject to flooding.	Good to fair	Fair to a depth of 10 inches, poor below.
New Cambria: Nc -----	Severe: slow permeability.	Slight -----	Moderate: texture.	Severe: high shrink-swell potential; high compressibility.	Severe (trench): texture. Slight (area).	Poor: texture.	Poor: clay texture.
Nd -----	Severe: slow permeability; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe (trench): subject to flooding. Severe (area): subject to flooding.	Poor: texture.	Poor: clay texture.
Nibson: Nx -----	Severe: bedrock at a depth of less than 20 inches; slope of 8 to 20 percent.	Severe: slope of 8 to 20 percent; bedrock at a depth of less than 20 inches.	Severe: less than 20 inches to bedrock.	Severe: bedrock at a depth of less than 20 inches; slope of 8 to 20 percent.	Severe (trench): bedrock at a depth of less than 20 inches; slope. Moderate to severe (area): slope.	Poor: coarse fragments; surface stones.	Poor: bedrock at a depth of less than 20 inches; slope of 8 to 20 percent; high pH.
Nuckolls ----- Mapped only with Harney soils.	Moderate: moderate permeability.	Moderate permeability; slope of 3 to 8 percent.	Slight -----	Moderate: low to moderate shrink-swell potential; medium to high compressibility.	Slight (trench). Slight (area).	Good -----	Good -----

*properties of the soils—Continued*

Suitability of the soil as a source of—continued			Soil features affecting—				
Sand and gravel	Road subgrade <sup>2</sup>	Road fill <sup>2</sup>	Highway location <sup>2</sup>	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions and waterways	Irrigation
Unsuited -----	Fair: fair stability.	Fair: fair shear strength.	Bedrock at a depth of less than 60 inches; high sodium content; moderate erodibility.	Slow permeability; bedrock at a depth of 40 to 60 inches.	Fair stability; fair to poor resistance to piping; fair shear strength; fair to good compaction.	Slow permeability; moderate erodibility; high pH in subsoil.	Generally not applicable.
Fair in substratum: poorly graded.	Good -----	Good -----	Subject to flooding; high erodibility.	Moderately rapid permeability.	Fair to poor stability; poor resistance to piping; high erodibility; fair compaction.	High erodibility.	Low available water capacity; moderately rapid intake rate.
Unsuited -----	Poor: high plasticity.	Poor: poor shear strength.	Slow permeability.	Slow permeability.	Poor stability; low shear strength; fair to poor compaction.	Silty clay surface layer.	High available water capacity; low intake rate; nearly level.
Unsuited -----	Poor: high plasticity.	Poor: poor shear strength.	Subject to flooding.	Slow permeability.	Poor stability; low shear strength; fair to poor compaction.	Silty clay surface layer.	Generally not applicable.
Unsuited -----	Fair: medium support.	Fair: fair shear strength.	Bedrock at a depth of less than 20 inches; moderate erodibility.	High seepage loss.	Fair to good stability; bedrock at a depth of less than 20 inches; limited borrow material.	Bedrock at a depth of less than 20 inches; slope of 8 to 20 percent.	Generally not applicable.
Unsuited -----	Good -----	Good -----	Slope of 3 to 8 percent; moderate erodibility.	Moderate permeability.	Fair stability; low to moderate shrink-swell potential; low to moderate shear strength; fair compaction.	Slope of 3 to 8 percent; high erodibility.	Generally not applicable.

TABLE 8.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of soil limitation for—					Suitability of the soil as a source of—	
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Foundations for low buildings	Sanitary <sup>1</sup> landfill	Cover material for sanitary landfill	Topsoil
Roxbury: Ro, Rp, Rr ----	Moderate to severe: moderate permeability; possible flooding.	Moderate to severe: subject to flooding.	Moderate to severe: subject to flooding.	Moderate to severe: low to moderate shrink-swell potential; subject to flooding.	Slight to severe (trench): subject to flooding in some areas. Slight to severe (area): subject to flooding in some areas.	Good -----	Good -----
*Timken: Tb, Tm ----- For Bogue part of Tb, see Bogue series. Shale outcrop in Tm is too variable to estimate.	Severe: shale at a depth of less than 20 inches; very slow permeability.	Severe: slope of 8 to 30 percent; shale at a depth of less than 20 inches.	Severe: shale at a depth of less than 20 inches.	Severe: very high shrink-swell potential; slope of 8 to 30 percent; subject to slides.	Severe (trench): shale at a depth of less than 20 inches. Moderate to severe (area): slope.	Poor: texture.	Poor: clay texture.
*Tobin: Tr ----- For the Roxbury part, see Roxbury series.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe (trench): subject to flooding. Severe (area): subject to flooding.	Good -----	Good -----
*Wakeen: Wm ----- For the Mento part, see Mento series.	Severe: bedrock at a depth of less than 40 inches.	Severe: slope; bedrock at a depth of less than 40 inches.	Severe: bedrock at a depth of less than 40 inches.	Moderate: bedrock at a depth of 2 to 3 feet; medium to high compressibility; slope.	Severe (trench): bedrock at a depth of less than 40 inches. Moderate (area): slope.	Fair: texture; slope.	Fair: slope of 8 to 20 percent.

<sup>1</sup> Onsite studies of the underlying strata, water tables, and hazards of aquifer pollution and drainage into ground water should be made for landfills deeper than 5 or 6 feet.

performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage and piping and is of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic material in a soil are among factors that are unfavorable.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or to other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulation of salts and alkali; depth of root zone; rate

*properties of the soils—Continued*

Suitability of the soil as a source of—continued			Soil features affecting				
Sand and gravel	Road subgrade <sup>2</sup>	Road fill <sup>2</sup>	Highway location <sup>2</sup>	Pond reservoir areas	Embankments, dikes, and levees	Terraces, diversions and waterways	Irrigation
Unsuited -----	Fair: fair stability.	Fair: fair shear strength.	Subject to flooding in some areas.	Moderate permeability.	Fair stability; fair shear strength; fair compaction.	No adverse features.	High available water capacity; moderate intake rate; nearly level; deep.
Unsuited -----	Poor: high plasticity.	Poor: poor shear strength.	Poor foundation material; slope of 8 to 30 percent; shale at a depth of less than 20 inches.	Very slow permeability.	Poor stability; poor shear strength; fair to poor compaction.	Shale at a depth of less than 20 inches; slope of 8 to 30 percent.	Generally not applicable.
Unsuited -----	Fair: fair soil support.	Fair: fair shear strength.	Subject to flooding.	Moderate permeability.	Fair to good stability; low to moderate shear strength; fair to good compaction.	Bottom of narrow drainage-ways.	High available water capacity; moderate intake rate; nearly level; deep; subject to flooding.
Unsuited -----	Poor: low soil support.	Fair: fair shear strength.	Bedrock at a depth of less than 40 inches; moderate erodibility.	Bedrock at a depth of less than 40 inches; moderate permeability.	Fair stability; moderate shear strength; fair compaction; bedrock at a depth of 2 to 3 feet.	High erodibility; bedrock at a depth of 2 to 3 feet; high pH.	Generally not applicable.

<sup>2</sup> Estimates were made with the assistance of NORMAN CLARK, engineer of soils, and HUBERT E. WORLEY, soils research engineer, Kansas State Highway Commission.

of water intake at the surface; permeability below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and need for drainage, or depth to water table or bedrock.

### ***Formation and Classification of the Soils***

This section tells how the factors of soil formation have affected the development of soils in Osborne County. It also explains the system of soil classification

currently used and places each soil series in the classes of that system.

### **Factors of Soil Formation**

Soil is formed by processes that act on parent material. Characteristics of the soil are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the factors of soil formation have acted on the parent material.

Climate and plants and animals are the active forces of soil formation. They act on the parent material that has accumulated from the weathering of rocks, and they slowly change it into soil. All five factors come into play in the formation of every soil. The effects of climate and plants and animals are conditioned by relief. The parent material also affects the kind of soil that is formed and, in some places, determines it almost entirely. Finally, time is needed for changing the parent material into a soil. It can be a short time or a long time that is needed for the differentiation of soil horizons. A long time generally is needed for distinct horizons to develop.

### **Parent material**

The material from which the soils of Osborne County developed ranges in age from Cretaceous (Gulfian) to Holocene. The oldest parent material in the county is marine Cretaceous rock and is represented by Greenhorn Limestone, Carlisle Shale, and the Niobrara Formation.

In the western part of the county, south of the South Fork of the Solomon River, remnants of the Ogallala Formation of the Pliocene Epoch (Tertiary) are present. These Tertiary rocks are represented by outcrops of mortar beds, opaline sandstone, and volcanic ash. This formation has not influenced the development and classification of soils in the county, except in small, isolated areas.

In the Quaternary Period, important geologic changes began late in the Pleistocene Epoch and continued intermittently into the Holocene Epoch. Much of the present topography of the county is the result of erosion and other geologic changes and of climatic changes during this period. The parent material of the Pleistocene Epoch is represented by loess and other silty material deposited during Illinoian and Wisconsin times. During this period small valleys and toe slopes of limestone hills also were filled with mixed silt, sand, and limestone gravel that washed from areas of loess and of limestone and shale.

Most of the alluvium is Holocene in age, and streams are still depositing this material. In local areas of the flood plain of the North Fork of the Solomon River, winds during the Holocene Epoch formed dunes from the alluvial sand (5).

The materials from which the soils of Osborne County formed are discussed in the following paragraphs.

**Loess.**—Loess consists of almost grit-free material that was deposited by wind. Harney, Mento, and Nuckolls soils formed from loess. They are the most extensive soils in Osborne County.

**Limestone.**—Brownell and Wakeen soils formed from material that weathered from Smoky Hill Chalk, and Heizer and other Brownell soils developed in material that weathered from Fort Hays Limestone (fig. 26). These are limestones of the Niobrara Formation. Nibson soils formed from material that weathered from the interbedded limestone and shale of the Greenhorn Formation (fig. 27).

**Shale.**—Two kinds of Carlisle Shale are in the county. One kind, the Blue Hill, is an acid and dark-colored fissile shale that is under Fort Hays Limestone. It has many zones of calcareous septarian and ordinary concretions. Bogue and Timken soils formed from material that weathered from this shale. Another kind, the Fairport Chalk, is between Greenhorn Limestone and Blue Hill Shale. Corinth soils developed in material that weathered from Fairport Chalk. Codell Sandstone is between Fort Hays Limestone and Blue Hill Shale. This formation has not influenced the development and classification of soils in the county, except in small, isolated areas. Fossils of shark teeth or vertebrae occur in the soft Codell Sandstone.

**Colluvium.**—Armo and Roxbury soils developed in mixed colluvial material on the lower slopes next to limestone uplands. The colluvium washed to valley fans and valley fills from upland areas of loess, limestone, and shale.



Figure 26.—Heizer and Brownell soils developed in this thick, massive Fort Hays limestone.

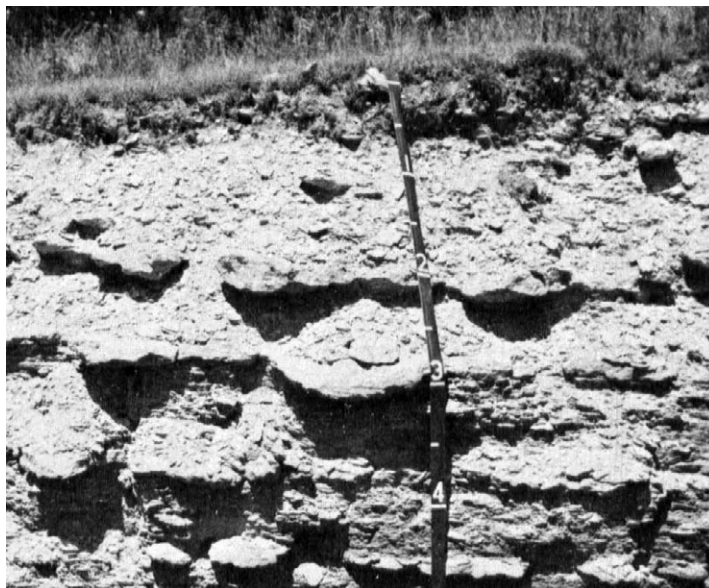


Figure 27.—Nibson soils developed in this interbedded limestone and shale of the Greenhorn Formation.



*Alluvium.*—The soils that develop in alluvium are young. The alluvium ranges from clay to sand and is the parent material of McCook, Detroit, Hord, and New Cambria soils. These soils are on terraces and are seldom flooded. The Munjor, Roxbury, Inavale, and Tobin soils, which also formed from alluvium, are on the less stable flood plains.

### **Climate**

Climate is an active factor of soil formation. It directly influences the formation of a soil by causing the parent material to weather. Its effect on plants and animals is an indirect influence.

The climate of Osborne County is continental, and it changes from dry to moist and subhumid. These changes can occur within a year or in cycles of several years. In dry periods, precipitation and humidity are well below normal, and the temperature above normal. In wet periods, precipitation and humidity are considerably above normal, and the temperature is normal or below normal.

The soil material dries to varying depths during dry periods. It slowly regains moisture during wet periods and can become so saturated that excess moisture penetrates the underlying material. Accumulations of soft lime in the underlying material of Harney soils are an indication of this excess moisture.

This wetting and drying has helped in the development of the soil, because the bases have been leached from the surface horizon and even from the B horizon of some more mature soils such as Detroit soils. This leaching leaves the surface layer very slightly acid and the B horizon at least neutral. Mature soils have distinct structure. Soils having well-developed horizons generally formed in gently sloping areas rather than in steep areas, because more moisture penetrates the gently sloping areas.

Weather records in Osborne County show that winters are short and cold, and summers are long and hot. About 75 percent of the precipitation falls during a long growing season. The rainfall in the growing season helps maintain the mid and tall grasses. These plants, in turn, reduce erosion, remove bases, and add organic matter to the upper part of the soil.

### **Plant and animal life**

All plants and animals are important to soil formation. Plants generally influence the amount of nutrients and of organic matter in the soil and the color of the surface layer. Animals such as earthworms, cicadas, and burrowing animals help keep the soil open and porous. Earthworms in McCook soils have left many worm casts. Bacteria and fungi help the plants decompose, thus releasing more nutrients for plant food.

The mid and tall prairie grasses have had the greatest influence on soil formation in Osborne County. As a result of the grasses, a typical soil in the county has a dark-colored upper part that is high in organic matter; a transitional part that in many places is slightly finer and somewhat lighter than the layer above; and the underlying parent material that generally is light in color and high in calcium carbonate.

### **Relief**

Relief, or lay of the land, influences the formation of

soils through its effect on drainage, runoff, plant cover, and soil temperature. Although climate and plants are the most active factors in the formation of soils, relief is important because it modifies the change from parent material to soil. Relief is an influence mainly because it controls the movement of water on the surface and into the soil. Partly because their slope is steep, thin soils such as Heizer soils formed from some of the oldest parent materials in the county. Brownell soils formed in the same parent material as Heizer soils, but in less steep areas; consequently they are thicker than the Heizer soils.

At the other extreme, moderately well developed soils on terraces formed from some of the youngest parent material in the county. These soils are in broad areas where the slope is nearly level to gentle and runoff is very slow. In these areas most of the precipitation penetrates the soil. The temperature of the soil is slightly lower on the east- and north-facing slopes than on west- and south-facing slopes.

### **Time**

In the formation of soils, a long time generally is needed to form distinct horizons in the soil from parent material. The differences in the length of time that the parent materials have been in place are commonly reflected in the degree of development of the soil profile. Some soils develop rapidly, others slowly.

The soils in Osborne County range from immature to mature. Soils on low bottoms are subject to stream overflow. They receive new sediment with each flooding. These soils have a thick, dark-colored surface layer, but they have weak soil structure. The continual addition of sediment accounts in part for the retarded formation of some soils, for example, the Tobin soils. The Heizer and Brownell soils are immature; their horizons are not well-developed. The Harney soils are mature.

### **Classification of the Soils**

Soils are classified so that their significant characteristics can be more easily remembered. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (6, 8).

The current system of classification has six categories. Beginning with the broadest, the categories are

TABLE 9.—*Classification of soil series*

Series	Family	Subgroup	Order
Armo -----	Fine-loamy, mixed, mesic -----	Typic Haplustolls -----	Mollisols.
Bogue -----	Very fine, montmorillonitic, mesic -----	Udorthentic Pellusterts -----	Vertisols.
Brownell -----	Loamy-skeletal, carbonatic, mesic -----	Typic Haplustolls -----	Mollisols.
Corinth -----	Fine, mixed, mesic -----	Typic Ustochrepts -----	Inceptisols.
Detroit -----	Fine, montmorillonitic, mesic -----	Pachic Argiustolls -----	Mollisols.
Harney -----	Fine, montmorillonitic, mesic -----	Typic Argiustolls -----	Mollisols.
Heizer -----	Loamy-skeletal, carbonatic, mesic -----	Lithic Haplustolls -----	Mollisols.
Hord -----	Silty, mixed, mesic -----	Pachic Haplustolls -----	Mollisols.
Inavale -----	Sandy, mesic -----	Typic Ustipsamments -----	Entisols.
McCook -----	Fine, montmorillonitic, mesic -----	Typic Argiustolls -----	Mollisols.
Mento -----	Coarse-silty, mixed, mesic -----	Fluventic Haplustolls -----	Mollisols.
Munjoy -----	Coarse-loamy, mixed (calcareous), mesic -----	Typic Ustifluvents -----	Entisols.
New Cambria -----	Fine, montmorillonitic, mesic -----	Cumulic Haplustolls -----	Mollisols.
Nibson -----	Loamy, carbonatic, mesic, shallow -----	Typic Haplustolls -----	Mollisols.
Nuckolls -----	Fine-silty, mixed, mesic -----	Typic Haplustolls -----	Mollisols.
Roxbury -----	Fine-silty, mixed, mesic -----	Cumulic Haplustolls -----	Mollisols.
Timken -----	Clayey, montmorillonitic, nonacid, mesic, shallow -----	Typic Ustorthents -----	Entisols.
Tobin -----	Fine-silty, mixed, mesic -----	Cumulic Haplustolls -----	Mollisols.
Wakeen -----	Fine-silty, carbonatic, mesic -----	Typic Haplustolls -----	Mollisols.

order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. In table 9, the soil series of Osborne County are placed in higher categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

**ORDER.** Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Ent-i-sol). Entisols, Vertisols, Inceptisols, and Mollisols are the four soil orders in Osborne County.

Entisols are mineral soils that formed recently. They have little or no evidence of genetic horizons and no features that show soil mixing caused by shrinking and swelling.

Vertisols are mineral soils that have a high content of clay and show evidence of soil mixing caused by shrinking and swelling.

Inceptisols are mineral soils that have weak genetic horizons. The surface layer is generally lighter in color than that of Mollisols. Inceptisols have no features that show soil mixing caused by shrinking and swelling.

Mollisols are mineral soils that have a thick, dark-colored surface layer that contains colloids dominated by bivalent cations. They have no features that show soil mixing caused by shrinking and swelling.

**SUBORDER.** Each order is subdivided into suborders that are based primarily on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of water-logging, or soil differences resulting from the climate or vege-

tation. The names of suborders have two syllables. The last syllable indicates the order.

**GREAT GROUP.** Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder.

**SUBGROUP.** Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group.

**FAMILY.** Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

## General Nature of the County

This section tells about the physiography, drainage, and water supply; the climate; and the farming in Osborne County. Unless otherwise indicated, the statistics used are from the Census of Agriculture and

the Kansas State Board of Agriculture Crop and Livestock Report.

### History and Development

The first settlement in Osborne County, in 1870, was in the area now called Bethany Township. The county was organized in 1871. The population has increased from 33 in 1870 to 6,416 in 1970. In 1959 there 940 farms in the county, and their average size was 589 acres. By 1970 the number of farms had decreased to 827, and their average size was 666 acres.

### Physiography, Relief, and Drainage

The physiography of Osborne County can be divided into three areas. The western part of the county is the highest in elevation. This area is table land in the High Plains; it is nearly level to gently sloping and has narrow, shallow drainageways. This area breaks rapidly into the Dissected High Plains in the eastern part. The Smoky Hills dominate the eastern parts of the county. The elevation ranges from about 1,400 feet in the Solomon River Valley near Downs in the eastern part to about 2,100 feet on the top of the divides in the west-central part.

Limestone-capped hills extend into Osborne County in two long points, one north and the other south of the South Fork of the Solomon River. These points are dissected by tributaries of the Solomon River. The row of hills south of the Solomon River extends eastward across the south-central part of the county, creating a narrow divide between two drainage patterns. The

landscape is abraded between widely spaced cuestas capped by limestone. From these hills the relief blends into a rolling upland plain dissected by tributaries of the Solomon River.

Most of Osborne County is drained by the South and North Forks of the Solomon River and their tributaries. The major stream of the county is the South Fork of the Solomon River. Narrow flood plains and broad terraces border the Solomon River. The tributaries of the Solomon River are small and have narrow valleys. In general they drain no more than two townships. The southern row of townships is drained by tributaries of the Saline River. Paradise Creek is the largest of these tributaries.

### Climate<sup>8</sup>

Osborne County has a continental climate. It has large variations in daily and annual temperatures, light to moderate precipitation, considerable sunshine, low humidity, moderate winds, and a maximum amount of rainfall late in spring and in summer. In table 10, temperature and precipitation data are given for the county. Table 11 shows the probabilities of freezing temperatures for central Osborne County (3).

The principal source of precipitation in Kansas is the Gulf of Mexico (4). Much cloudiness and precipitation follow when warm, moist air from the Gulf flows northward and collides over Kansas with colder air from the North. Because the flow of Gulf air is much

<sup>8</sup> By MERLE J. BROWN, climatologist for Kansas, National Weather Service, U.S. Department of Commerce, at Manhattan.

TABLE 10.—*Temperature and precipitation*

[From records kept at Alton, Osborne County, Kansas]

Month	Temperature				Precipitation		
	Average daily maximum <sup>1</sup>	Average daily minimum <sup>1</sup>	Two years in 10 will have about 4 days with—		Average <sup>2</sup>	One year in 10 will have—	
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—
	° F	° F	° F	° F	Inches	Inches	Inches
January -----	40.7	14.6	60	−4	0.61	0.01	1.51
February -----	46.4	19.2	66	2	.85	.06	1.92
March -----	56.2	27.3	77	8	1.24	.02	2.68
April -----	68.1	39.2	85	25	2.23	.51	4.32
May -----	76.4	49.9	91	36	3.24	1.31	5.24
June -----	86.6	60.5	102	49	3.92	.71	6.96
July -----	93.2	65.8	106	57	3.27	.62	6.54
August -----	92.2	64.3	106	54	2.67	.68	4.30
September -----	83.7	54.9	100	39	2.50	.48	5.06
October -----	72.0	42.5	88	28	1.49	.23	3.09
November -----	56.2	27.9	73	12	.92	.02	2.19
December -----	43.8	18.3	63	4	.61	.01	1.51
Year -----	68.0	40.4	<sup>3</sup> 107	<sup>4</sup> −13	23.57	13.86	31.95

<sup>1</sup> 1903-1970.

<sup>2</sup> 1879-1970.

<sup>3</sup> Average annual highest temperature.

<sup>4</sup> Average annual lowest temperature.

TABLE 11.—*Freeze dates in spring and fall*

Probability	Dates for given probability at temperature of—				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than -----	April 5	April 13	April 18	April 28	May 13
2 years in 10 later than -----	March 30	April 7	April 13	April 23	May 8
5 years in 10 later than -----	March 18	March 28	April 4	April 13	April 28
Fall:					
1 year in 10 earlier than -----	November 4	October 25	October 18	October 10	September 29
2 years in 10 earlier than -----	November 10	October 30	October 22	October 15	October 3
5 years in 10 earlier than -----	November 22	November 10	November 1	October 24	October 13

more frequent over the eastern part of Kansas than over the western part, a pronounced rainfall gradient runs across the state. The average annual precipitation increases from 16 inches in the western part of Kansas to 23.5 inches in Osborne County and to 40 inches in the eastern part.

Osborne County is in the drier half of the state, but the lack of rainfall is partly offset by the seasonal distribution of precipitation. Over three-fourths of the precipitation falls during the growing season, April through October. The average rainfall is more than 2.5 inches each month, May through August. June, the month of greatest precipitation, has an average of nearly 4 inches. Winters are dry. Only 9 percent of the annual precipitation falls in December, January, and February. Precipitation during November through February is less than 1 inch each month.

According to records kept at the weather station near Alton, the lowest annual precipitation in the period 1878 to 1970 was 12.78 inches in 1917, and the highest was 43.86 inches in 1891. Some months had no measurable precipitation, but a few months had more than 11 inches. Consecutive periods of dry weather are not uncommon, and droughts that last several years occur at irregular intervals. The most devastating drought lasted from 1932 through 1939; in this period the annual precipitation was about 5.5 inches below the long-term average.

On the average, 63 days per year have measurable precipitation. On 18 of these days, the precipitation is 0.10 inch or less each day. This precipitation is of little benefit during the growing season, because it wets only a few inches of the surface layer and is lost rapidly through evaporation. Thunderstorms occur during the warm season. They are occasionally violent and can produce heavy rain, large hail, and strong winds. These severe storms generally are short and local in extent. Hail is most damaging when it falls in May or June, before the winter wheat is harvested.

Because the climate is continental and the air generally is dry, the weather warms rapidly on sunny days, and nights are markedly cooler. The daily temperature variation averages 27.5°. It varies most in spring. Average temperatures range from 27.7° F in January to 79.5° in July. The intense solar heating during long summer days and the periodic surges of cold arctic air in winter contribute to this wide range

in annual temperature. The transition from warm to cold seasons is rapid. The average temperature in October is 57.3°; in November it drops to 42.1°. Temperature extremes for the period of record range from -29° to 121°. The highest temperature on record for Kansas is 121°.

The average freeze-free period in Osborne County is more than 5.5 months and extends from late in April to mid-October. Little crop damage is caused by freezing weather in most years, although freezes late in spring occasionally damage winter wheat.

Osborne County gets about 21 inches of snow per year. Snowfall ranges from 1 inch (1913-1914) to 51 inches (1911-1912). Blizzards occur occasionally, especially early in spring, but these storms generally don't last long.

The prevailing wind direction is southerly, but northerly winds are not uncommon, particularly in winter. The average wind velocity is moderately strong in all seasons and reaches a maximum in spring. Average hourly velocity in March, the windiest month, is about 14 miles per hour.

## Water Supply

Ground-water supplies for livestock and domestic use range from abundant in the Solomon River valleys to adequate in some of the tributaries. In other areas, underground water supplies are not adequate for existing needs, and farmers and ranchers depend on runoff to fill stockwater ponds and pits (fig. 28). Shallow low-producing wells are the main source of water for domestic use.

Underground water is an extremely limited source of irrigation water. A few low-producing wells are in the valleys of the North and South Forks of the Solomon River. The stream flow of these forks is a reliable source of irrigation water except in periods of low rainfall. The main source of irrigation water in Osborne County is the Kirwin and Webster Reservoirs. Water from there is carried by canals of the Kirwin and Webster Irrigation Districts.

## Farming

In Osborne County, farming is growing cash crops and raising livestock, mainly beef cattle. In 1969, about

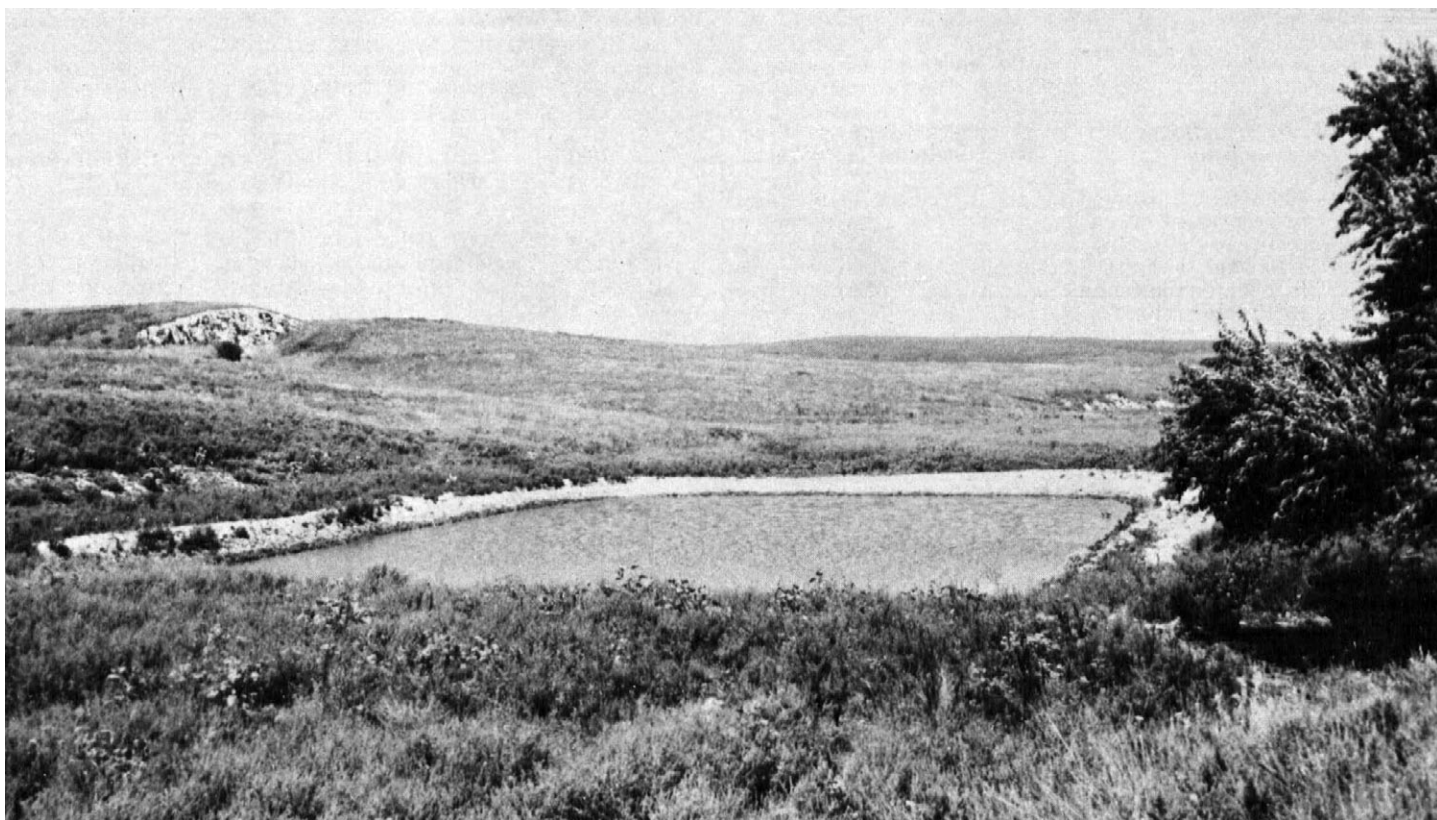


Figure 28.—Stockwater pit in Alluvial land, loamy.

300,000 acres were cultivated, and about 225,000 acres were used for range. About 10,000 acres were irrigated.

The main dryland crops are wheat and grain sorghum, but forage sorghum and alfalfa also are grown. The main irrigated crops are corn, grain sorghum, and forage sorghum. Some irrigated land is in soybeans and orchards. In 1969, wheat was grown on about 111,000 acres; grain sorghum on 25,000 acres; forage sorghum on 42,000 acres; corn on 6,800 acres; alfalfa on 10,000 acres; and wild hay on about 3,500 acres.

Beef cattle outnumber all other kinds of livestock. There are several small feedlots for beef cattle. Hogs and sheep vary in number from year to year.

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### Glossary

**Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

**Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

**Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Clay film.** A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

**Colluvium.** Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

**Concretions.** Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

**Consistence, soil.** The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

**Loose.**—Noncoherent when dry or moist; does not hold together in a mass.

**Friable.**—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

**Firm.**—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

**Plastic.**—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

**Sticky.**—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

**Hard.**—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

**Soft.**—When dry, breaks into powder or individual grains under very slight pressure.

**Cemented.**—Hard and brittle; little affected by moistening.

**Gravelly soil material.** From 15 to 50 percent of material by volume consists of rounded or angular rock fragments that are not prominently flattened and are up to 3 inches in diameter.

**Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

**O horizon.**—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

**A horizon.**—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

**B horizon.**—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

**C horizon.**—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

**R layer.**—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

**Loess.** Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

**Mottling, soil.** Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few*, *common*, and *many*; size—*fine*, *medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

**Parent material.** Disintegrated and partly weathered rock from which soil has formed.

**Permeability.** The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

**Poorly graded.** A soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles in poorly graded soil material, density can be increased only slightly by compaction.

**Profile, soil.** A vertical section of the soil through all its horizons and extending into the parent material.

**Reaction, soil.** The degree of acidity or alkalinity of a soil expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

pH		pH	
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly	
Slightly acid	6.1 to 6.5	alkaline	9.1 and higher
Neutral	6.6 to 7.3		

**Sand.** Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

**Sandy soils.** A broad term for soils of the sand and loamy sand classes; soil material with more than 70 percent sand and less than 15 percent clay.

**Silt.** Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

**Slick spots.** Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

**Solum.** The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either single *grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

**Subsoil.** Technically, the B horizon; roughly, the part of the solum below plow depth.

**Substratum.** Technically, the part of the soil below the solum.

**Surface layer.** A term used in nontechnical soil descriptions for one or more layers above the subsoil. Includes A horizon and part of B horizon; has no depth limit.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

**Texture, soil.** The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

**Tilth, soil.** The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

**Variant, soil.** A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.



# GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a range site or a windbreak suitability group, read the introduction to the section it is in for general information about its management.

Map symbol	Mapping unit	Page	Capability unit	Range site	Page	Windbreak suitability group
			Symbol	Name		Number
Aa	Alluvial land, loamy-----	9	VIw-2	Loamy Lowland	32	1
Ab	Alluvial land, mixed-----	10	IVw-1	Loamy Lowland	32	1
Ar	Armo silt loam, 3 to 7 percent slopes----	11	IIIe-3	Limy Upland	32	3
As	Armo silt loam, 3 to 7 percent slopes, eroded-----	11	IVe-3	Limy Upland	32	3
Ax	Armo-Bogue complex-----	11	VIe-1	-----	--	--
	Armo soil-----	--	-----	Limy Upland	32	3
	Bogue soil-----	--	-----	Blue Shale	31	4
Bo	Bogue clay, 3 to 15 percent slopes-----	12	VIe-1	Blue Shale	31	4
Bw	Brownell-Wakeen complex-----	13	VIe-2	Limy Upland	32	4
Co	Corinth silty clay loam, 3 to 7 percent slopes-----	14	IVe-4	Limy Upland	32	3
Cr	Corinth silty clay loam, 7 to 15 percent slopes-----	14	VIe-3	Limy Upland	32	3
De	Detroit silty clay loam-----	15	I-3	Loamy Terrace	32	1
Ha	Harney silt loam, 0 to 1 percent slopes---	16	IIC-1	Loamy Upland	32	2
Hb	Harney silt loam, 1 to 3 percent slopes---	16	IIe-1	Loamy Upland	32	2
Hc	Harney silt loam, 3 to 7 percent slopes---	16	IIIe-1	Loamy Upland	32	2
Hd	Harney silty clay loam, 2 to 7 percent slopes, eroded-----	16	IIIe-2	Loamy Upland	32	2
He	Harney-Mento complex, 1 to 3 percent slopes-----	16	IIe-2	Clay Upland	31	2
Hm	Harney-Mento complex, 3 to 7 percent slopes-----	17	IIIe-2	Clay Upland	31	2
Hn	Harney-Nuckolls complex, 3 to 8 percent slopes-----	17	IVe-1	Loamy Upland	32	2
Hx	Heizer-Brownell complex-----	18	VIIIs-1	-----	--	4
	Heizer soil-----	--	-----	Shallow Limy	33	--
	Brownell soil-----	--	-----	Limy Upland	32	--
Hx	Hord silt loam-----	19	I-1	Loamy Terrace	32	1
In	Inavale loamy fine sand-----	20	VIe-4	Sands	32	4
Ma	McCook silt loam-----	20	I-1	Loamy Terrace	32	1
Mc	Munjor-McCook complex-----	21	IIIw-1	-----	--	1
	Munjor soil-----	--	-----	Sandy Lowland	32	--
	McCook soil-----	--	-----	Loamy Lowland	32	--
Nc	New Cambria silty clay-----	22	IIIs-1	Clay Terrace	31	1
Nd	New Cambria silty clay, frequently flooded-----	22	VIw-1	Clay Lowland	31	1
Nx	Nibson complex-----	23	VIe-2	Limy Upland	32	4
Ro	Roxbury silt loam-----	24	I-1	Loamy Terrace	32	1
Rp	Roxbury silt loam, channeled-----	24	IIIe-4	Loamy Terrace	32	1
Rr	Roxbury complex-----	24	I-2	Loamy Terrace	32	1
Tb	Timken-Bogue clays-----	25	VIIIs-2	Blue Shale	31	4
Tm	Timken-Shale outcrop complex-----	25	VIIIs-2	Blue Shale	31	4
Tr	Tobin and Roxbury silt loams-----	25	IIw-1	Loamy Lowland	32	1
Wm	Wakeen-Mento complex, 3 to 8 percent slopes-----	26	IVe-2	Limy Upland	32	--
	Wakeen soil-----	--	-----	-----	--	3
	Mento soil-----	--	-----	-----	--	2



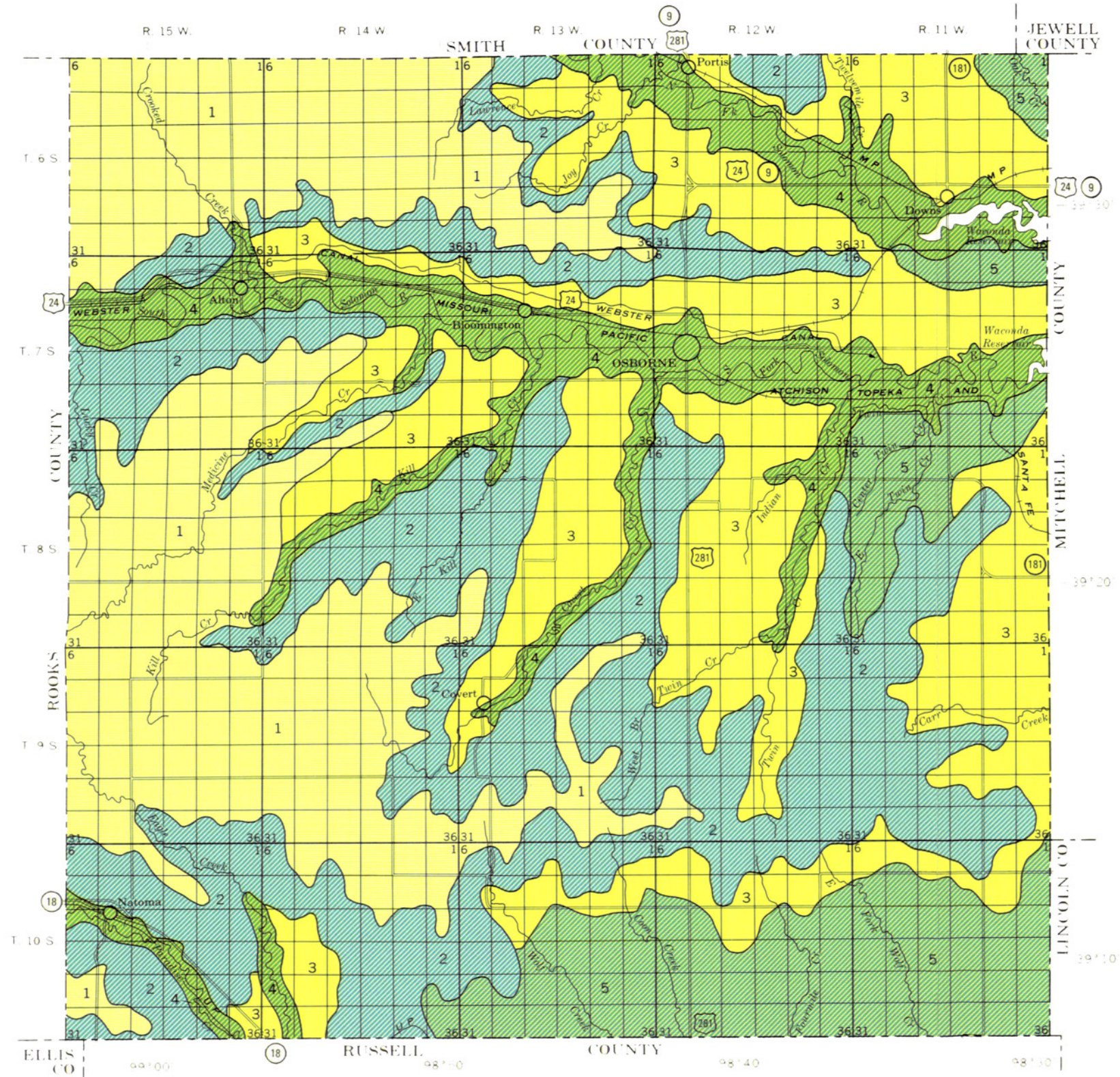
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U. S. DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE  
KANSAS AGRICULTURAL EXPERIMENT STATION

## GENERAL SOIL MAP OSBORNE COUNTY, KANSAS

Scale 1:253,440  
1 0 1 2 3 4 Miles

### SOIL ASSOCIATIONS \*

- 1** Harney-Mento-Brownell association: Deep and moderately deep, nearly level to steep, loamy soils formed in loess and material weathered from soft limestone; on uplands
- 2** Armo-Heizer-Bogue association: Deep to shallow, sloping to steep, loamy and clayey soils formed in material weathered from limestone and shale; on uplands
- 3** Harney-Nuckolls association: Deep, nearly level to sloping, loamy soils formed in loess; on uplands
- 4** Hord-Roxbury-McCook association: Deep, nearly level to gently undulating and sloping, loamy soils formed in alluvium; on flood plains and terraces
- 5** Harney-Corinth-Nibson association: Deep to shallow, nearly level to moderately steep, loamy and clayey soils formed in loess and material weathered from shale and limestone; on uplands

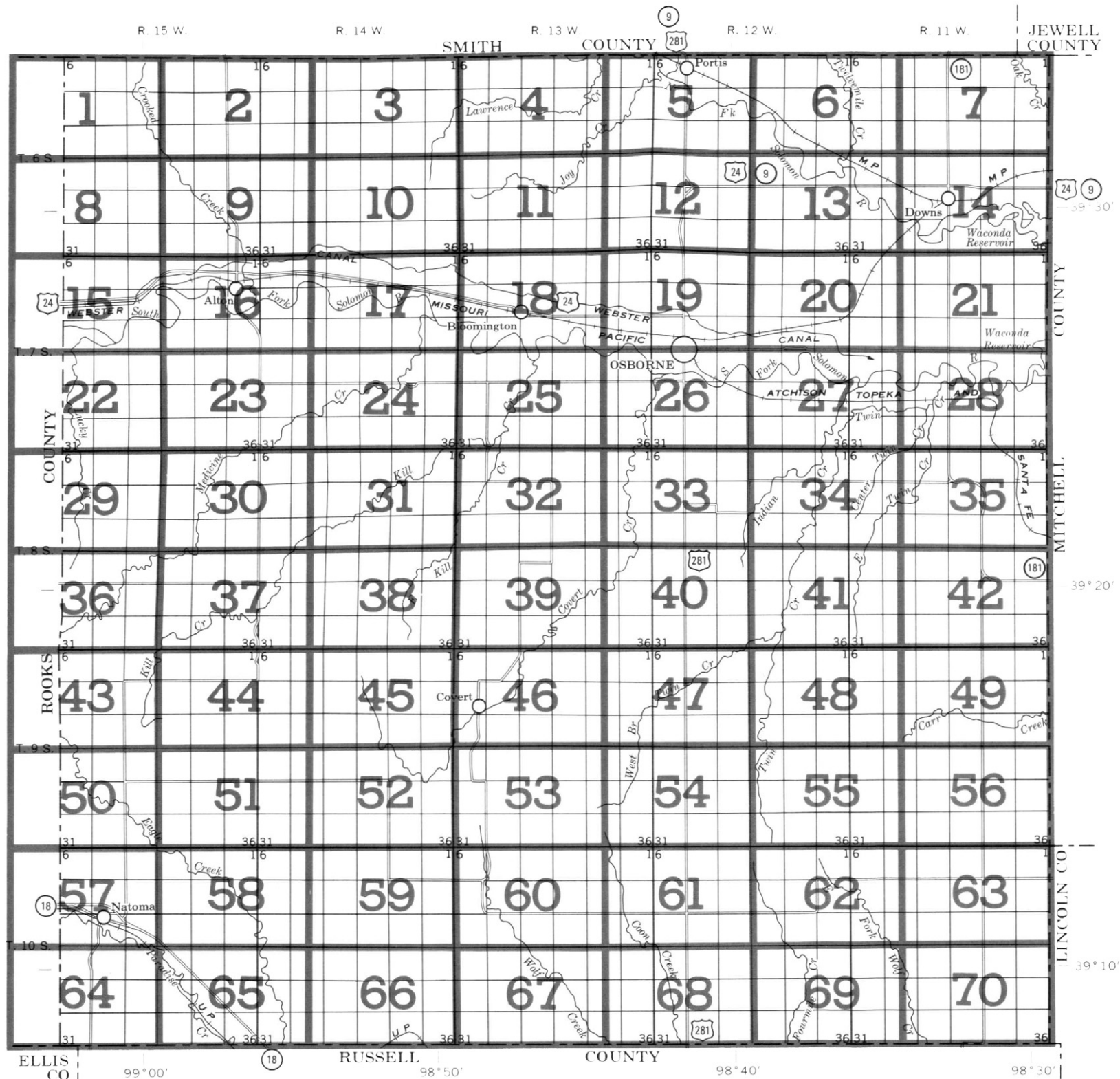
\* Textures apply to the surface layer and the subsoil of the major soils.

Compiled 1974

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

SECTIONALIZED TOWNSHIP					
6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36





INDEX TO MAP SHEETS  
OSBORNE COUNTY, KANSAS



SECTIONALIZED TOWNSHIP						
6	5	4	3	2	1	
7	8	9	10	11	12	
18	17	16	15	14	13	
19	20	21	22	23	24	
30	29	28	27	26	25	
31	32	33	34	35	36	

SOIL LEGEND

SYMBOL	NAME
Aa	Alluvial land, loamy
Ab	Alluvial land, mixed
Ar	Armo silt loam, 3 to 7 percent slopes
As	Armo silt loam, 3 to 7 percent slopes, eroded
Ax	Armo-Bogue complex
Bo	Bogue clay, 3 to 15 percent slopes
Bw	Brownell-Wakeen complex
Co	Corinth silty clay loam, 3 to 7 percent slopes
Cr	Corinth silty clay loam, 7 to 15 percent slopes
De	Detroit silty clay loam
Ha	Harney silt loam, 0 to 1 percent slopes
Hb	Harney silt loam, 1 to 3 percent slopes
Hc	Harney silt loam, 3 to 7 percent slopes
Hd	Harney silty clay loam, 2 to 7 percent slopes, eroded
He	Harney-Mento complex, 1 to 3 percent slopes
Hm	Harney-Mento complex, 3 to 7 percent slopes
Hn	Harney-Nuckolls complex, 3 to 8 percent slopes
Hx	Heizer-Brownell complex
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Nx	Nibson complex
Ro	Roxbury silt loam
Rp	Roxbury silt loam, channeled
Rr	Roxbury complex
Tb	Timken-Bogue clays
Tm	Timken-Shale outcrop complex
Tr	Tobin and Roxbury silt loams
Wm	Wakeen-Mento complex, 3 to 8 percent slopes

WORKS AND STRUCTURES

Highways and roads	
Divided .....	
Good motor .....	
Poor motor .....	
Trail .....	
Highway markers	
National Interstate .....	
U. S. ....	
State or county .....	
Railroads	
Single track .....	
Multiple track .....	
Abandoned .....	
Bridges and crossings	
Road .....	
Trail .....	
Railroad .....	
Ferry .....	
Ford .....	
Grade .....	
R. R. over .....	
R. R. under .....	
Buildings	
School .....	
Church .....	
Mine and quarry	
Gravel pit .....	
Power line	
Pipeline .....	
Cemetery .....	
Dams .....	
Levee .....	
Tanks .....	
Well, oil or gas .....	
Forest fire or lookout station .....	
Windmill .....	
Located object .....	

CONVENTIONAL SIGNS

BOUNDARIES

National or state .....	
County .....	
Minor civil division .....	
Reservation .....	
Land grant .....	
Small park, cemetery, airport ...	
Land survey division corners ...	

DRAINAGE

Streams, double-line	
Perennial .....	
Intermittent .....	
Streams, single-line	
Perennial .....	
Intermittent .....	
Crossable with tillage implements .....	
Not crossable with tillage implements .....	
Unclassified .....	
Canal or ditch, single-line irrigation	
Lakes and ponds	
Perennial .....	
Intermittent .....	
Spring .....	
Marsh or swamp .....	
Wet spot .....	
Drainage end or alluvial fan	

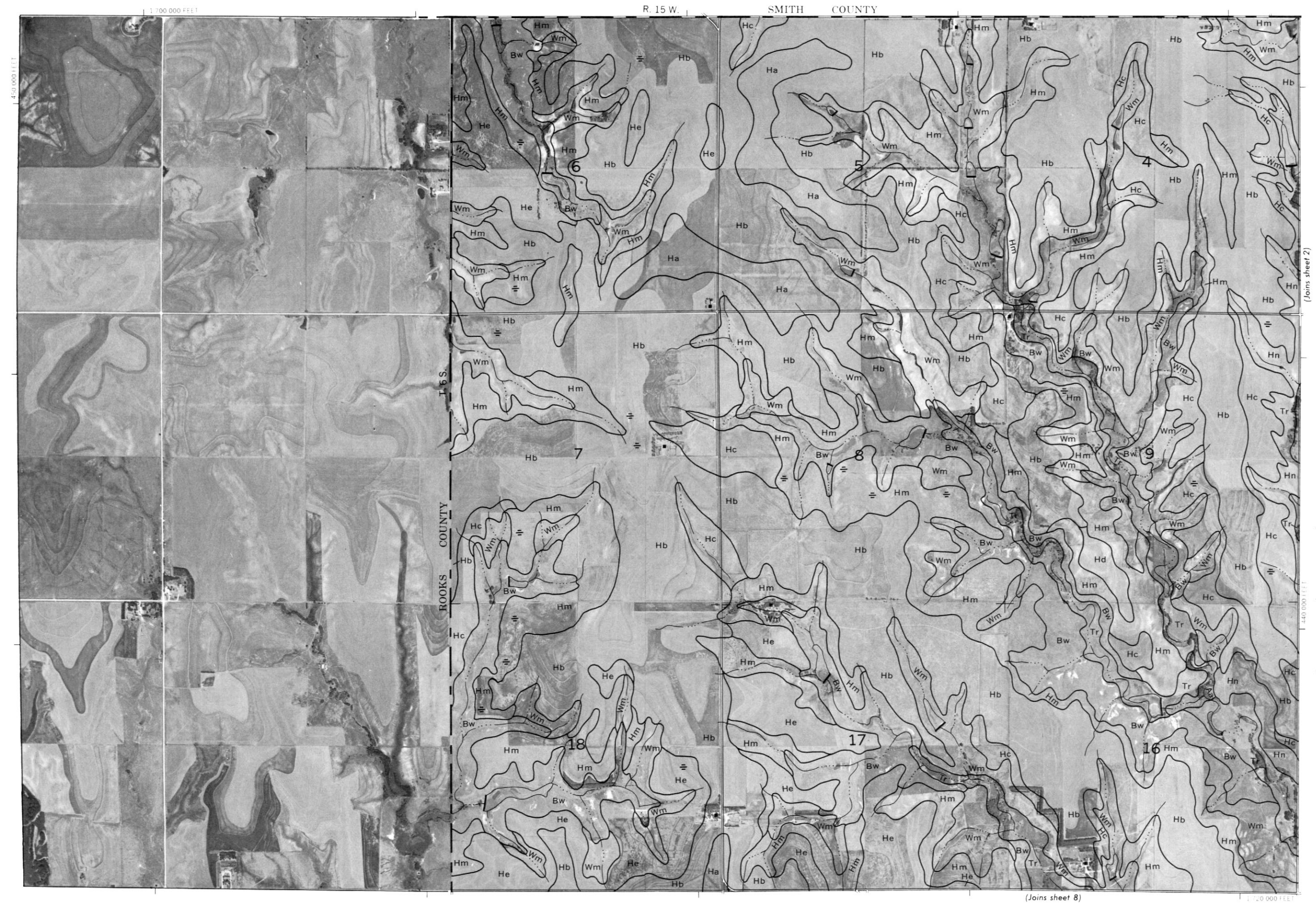
RELIEF

Escarpments	
Bedrock .....	
Other .....	
Short steep slope .....	
Prominent peak .....	
Depressions	
Crossable with tillage implements .....	
Not crossable with tillage implements .....	
Contains water most of the time .....	

SOIL SURVEY DATA

Soil boundary	
and symbol .....	
Gravel .....	
Stoniness {	
Stony .....	
Very stony .....	
Rock outcrops .....	
Chert fragments .....	
Clay spot .....	
Sand spot .....	
Gumbo or scabby spot .....	
Made land .....	
Severely eroded spot .....	
Blowout, wind erosion .....	
Gully .....	
Borrow pit .....	
Cut and fill land .....	









450 000 FEET

T. 6 S.

(Joins sheet 3)

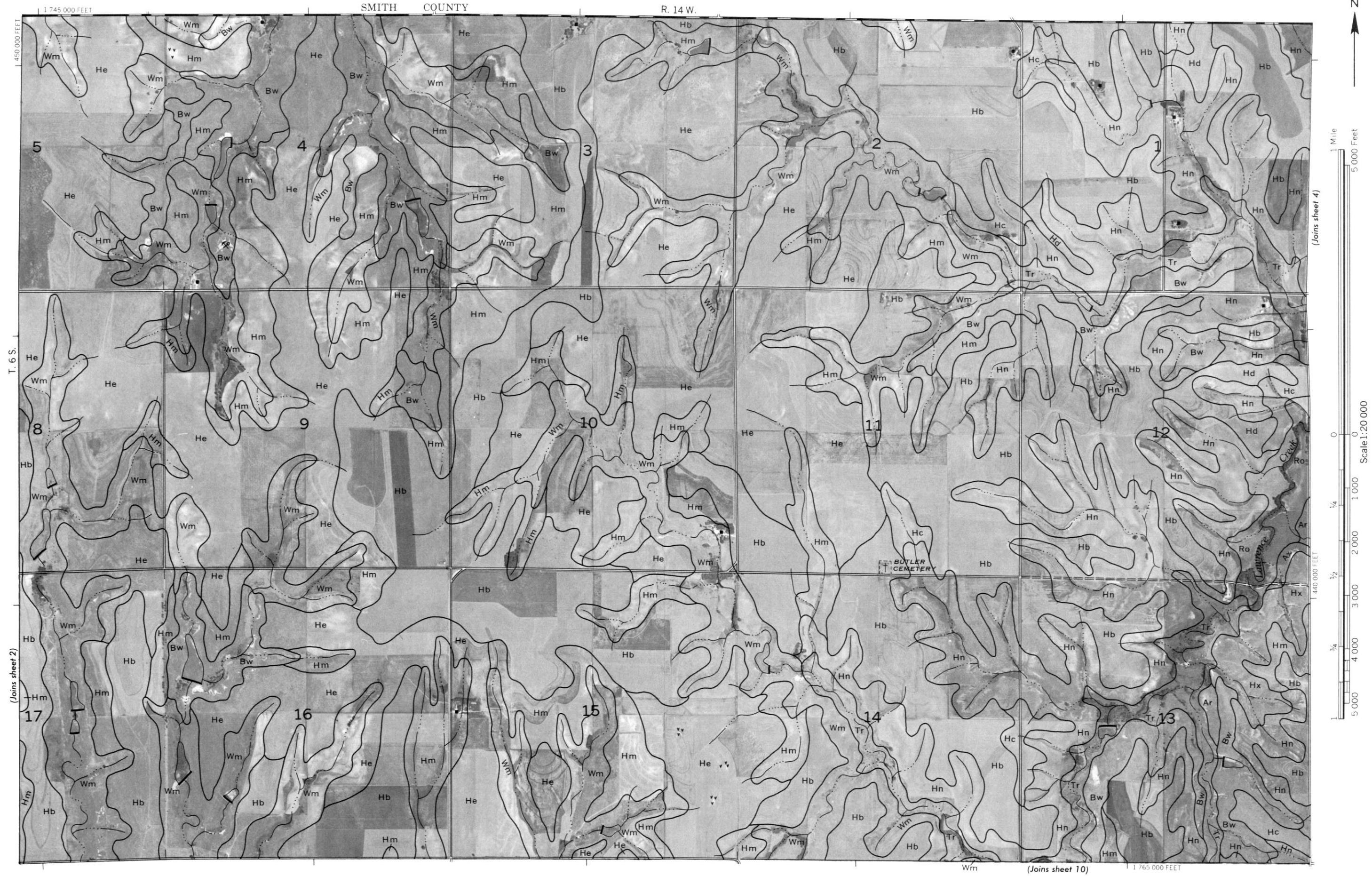
(Joins sheet 9)

Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5 000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



OSBORNE COUNTY, KANSAS NO. 3

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Scale 1:20 000

440 000 FEET

(Joins sheet 11)

Joins sheet 5)

T. 6 S.

450 000 FEET

Land division corners are approximately positioned on this map

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone

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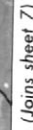
OSBORNE COUNTY, KANSAS NO. 4



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.





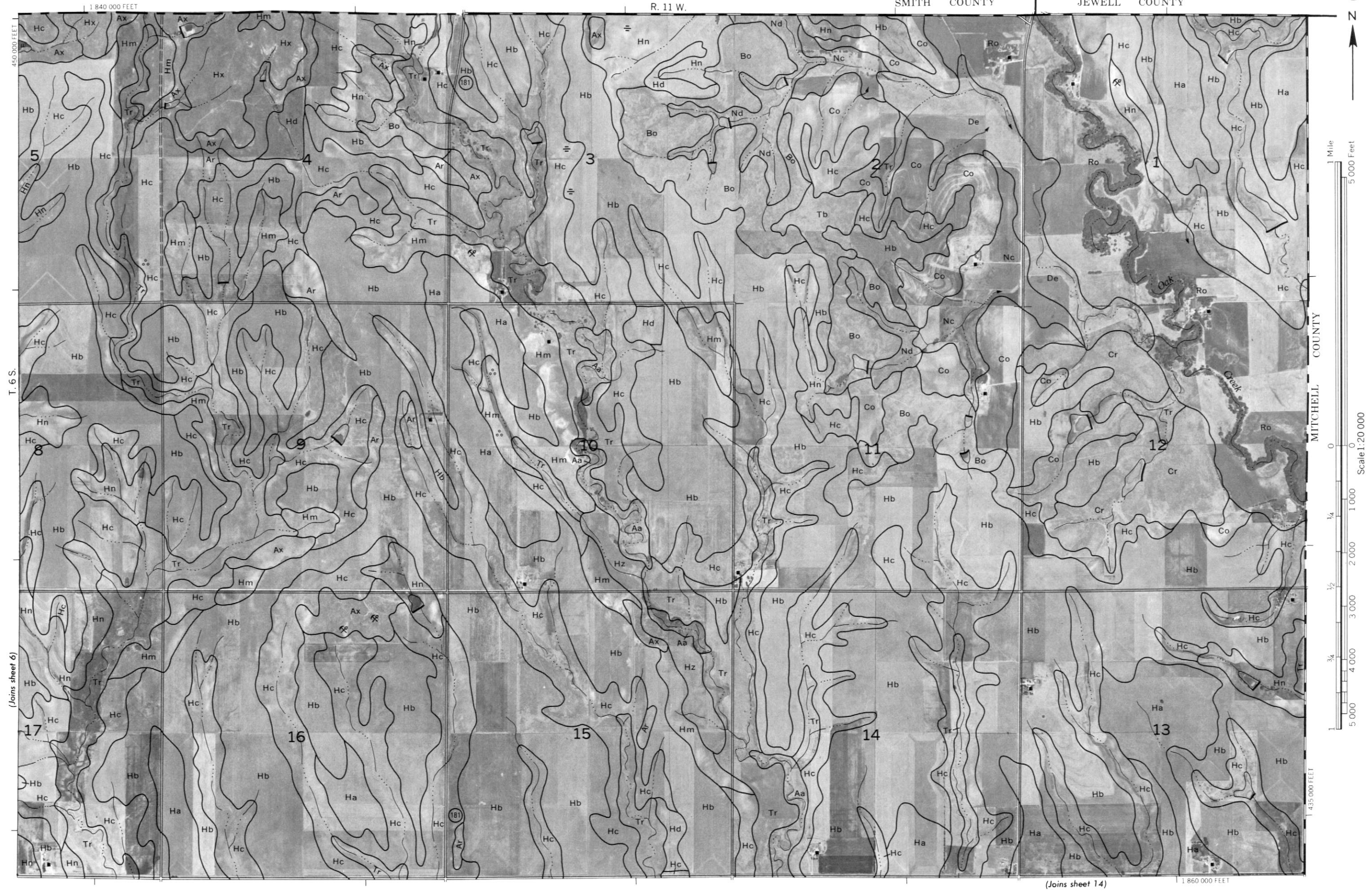


OSBORNE COUNTY, KANSAS NO. 6

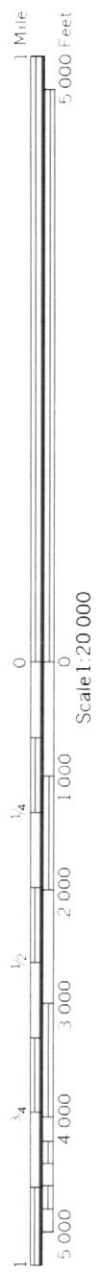


OSBORNE COUNTY, KANSAS NO. 7

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.



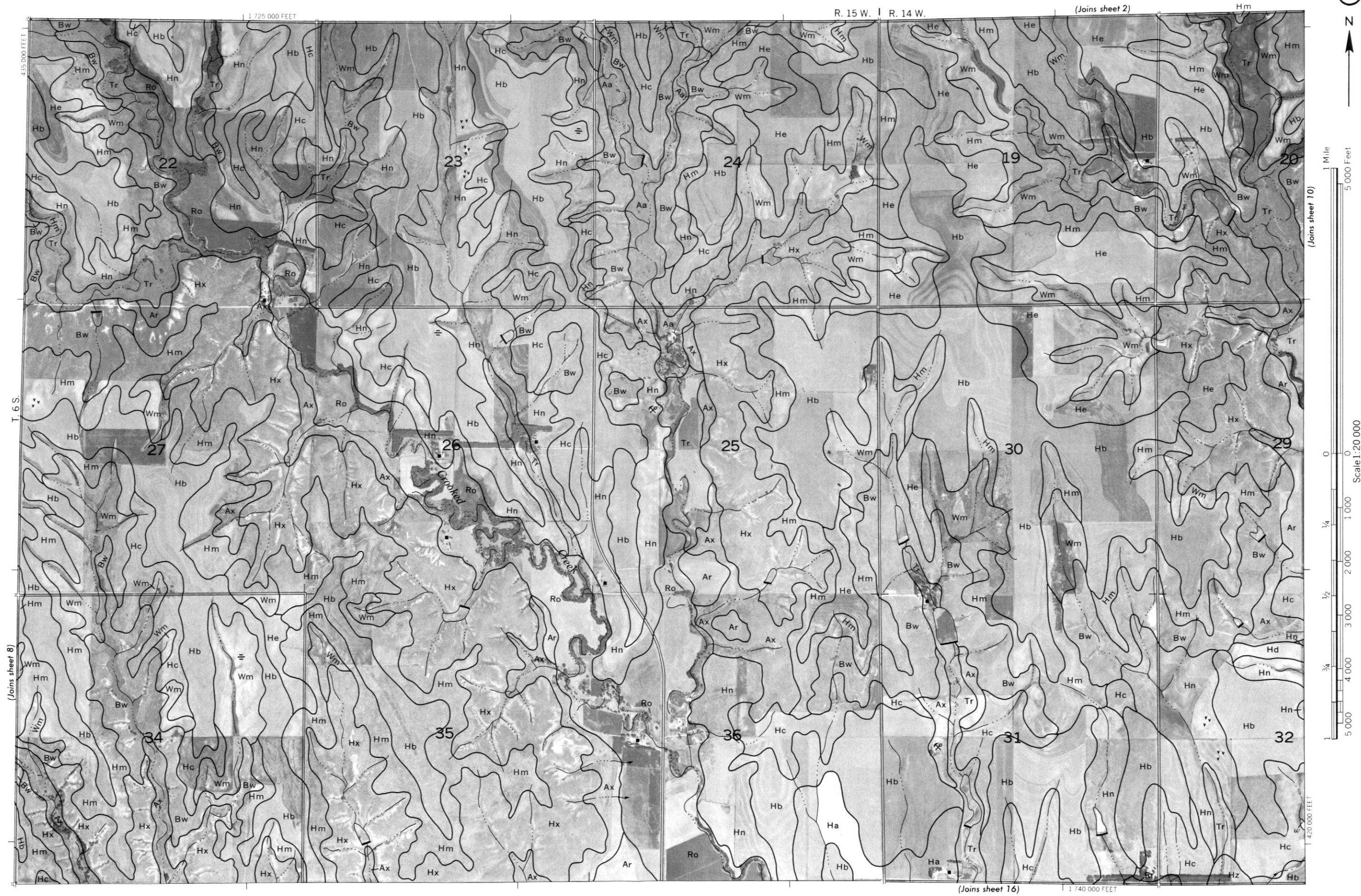




Land division corners are approximately positioned on this map.  
Photobase from 1941 aerial photography. Positions of 5,000-foot grid lines are approximate and based on the Kansas coordinate system north zone.  
This map is a reproduction of a map compiled in 1974 as part of a survey by the United States Department of Agriculture, Soil Conservation Service and the Kansas Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.







1 Mile  
5 000 Feet

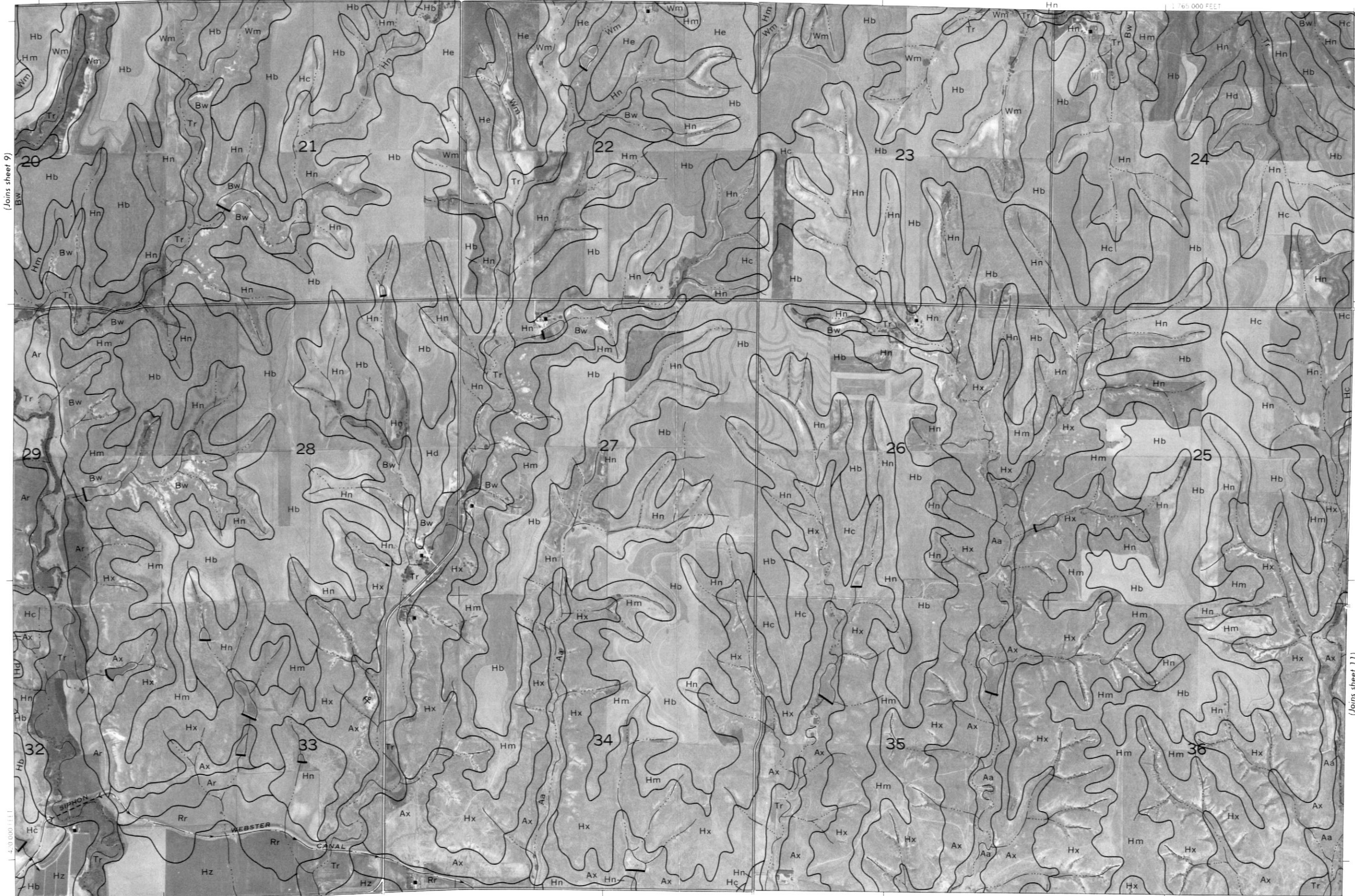
Scale 1:20 000

0 1 000 2 000 3 000 4 000 5 000

(Joins sheet 3)

R. 14 W.

1:250 000 FEET



SIPHON  
WEBSTER CANAL

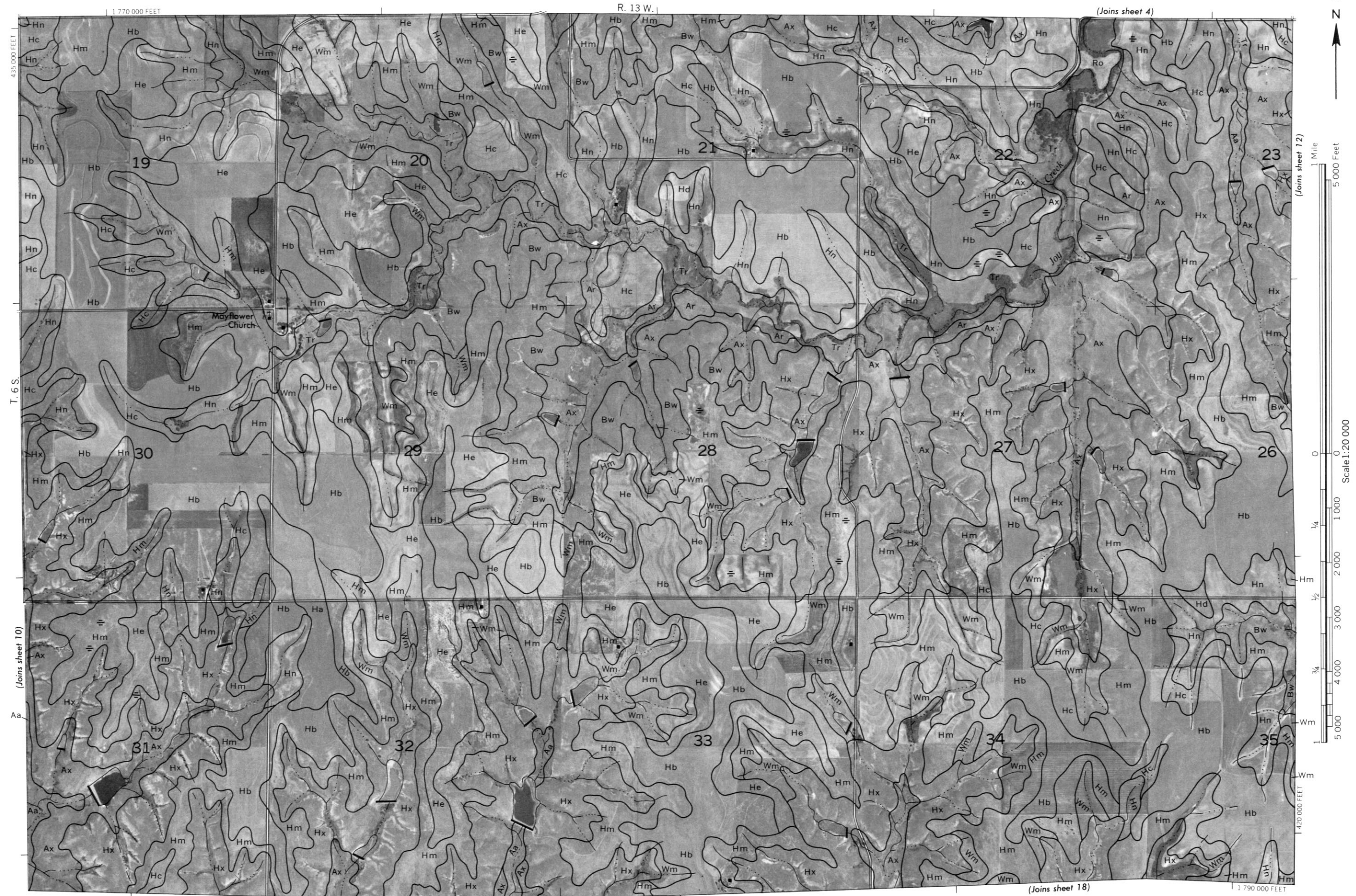
(Joins sheet 17)

(Joins sheet 11)

Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



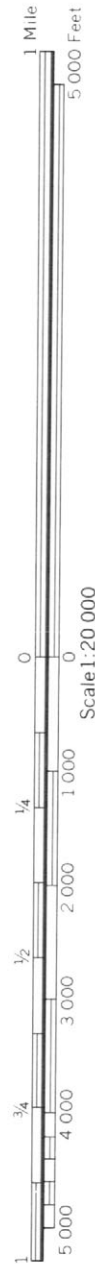
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.





(Joins sheet 5)

1 815 000 FEET



(Joins sheet 11)

Scale 1:20 000

420 000 FEET

1 795 000 FEET

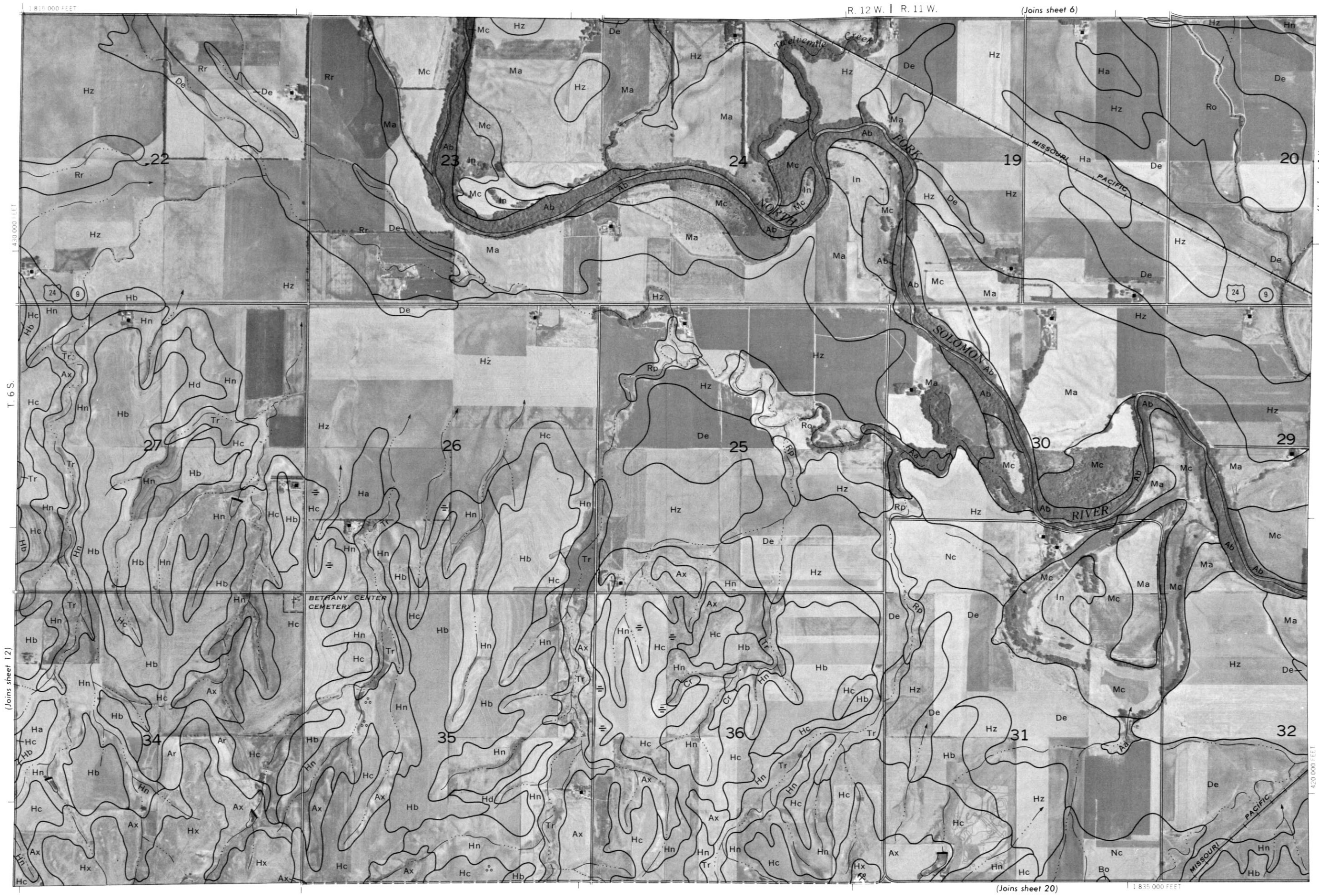
(Joins sheet 19)

(Joins sheet 13)

T. 6 S.

Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

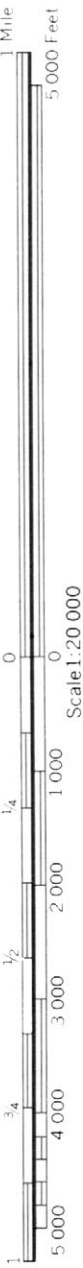




(Joins sheet 12)

(Joins sheet 14)

(Joins sheet 20)



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate, and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.

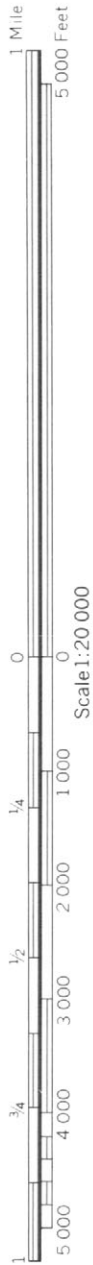




(Joins sheet 7)

R. 11 W.

1 860 000 FEET



(Joins sheet 13)

Scale 1:20 000

1 420 000 FEET



1 840 000 FEET

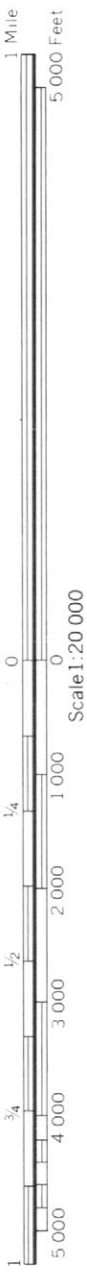
(Joins sheet 21)

Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.





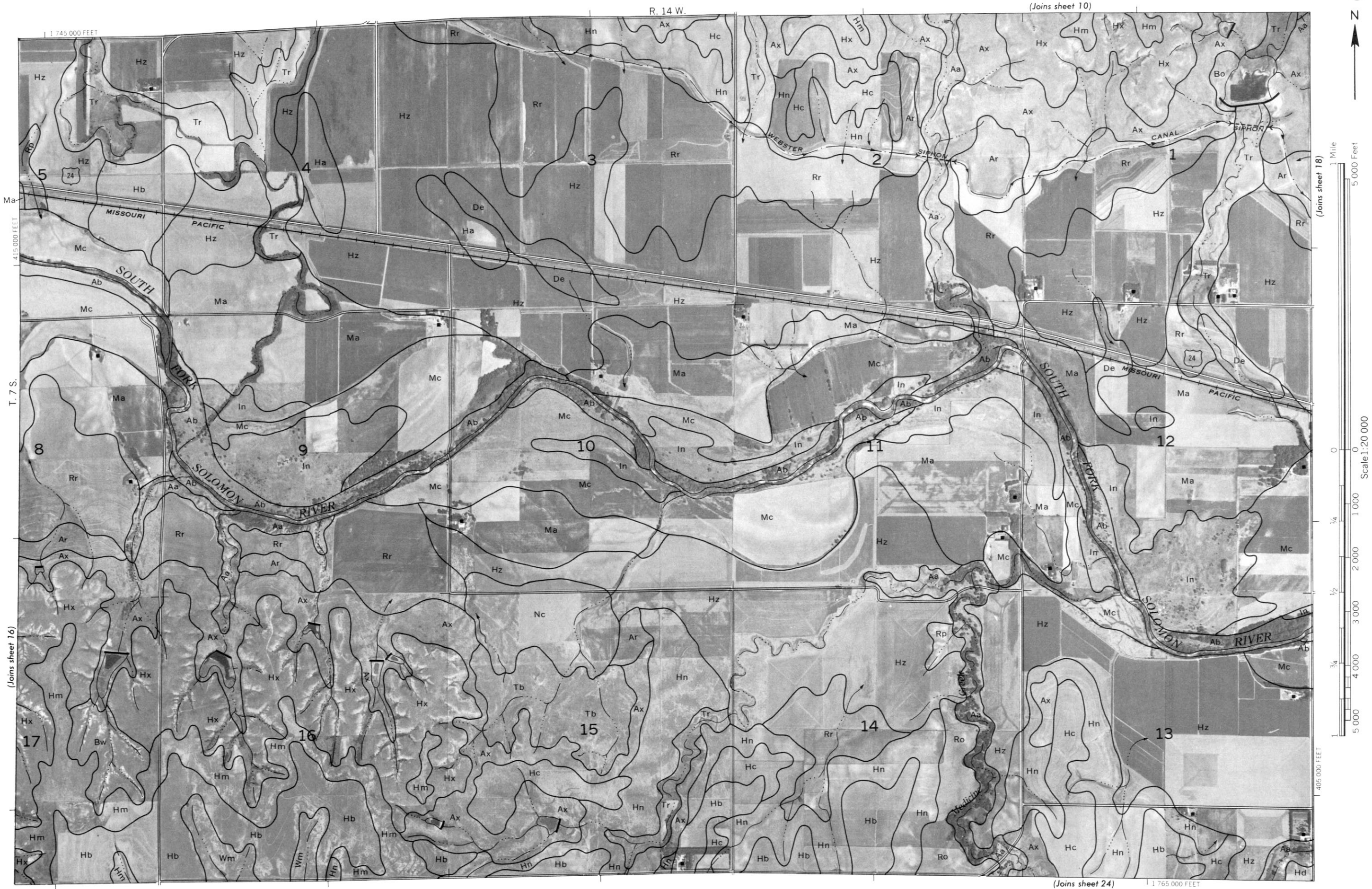




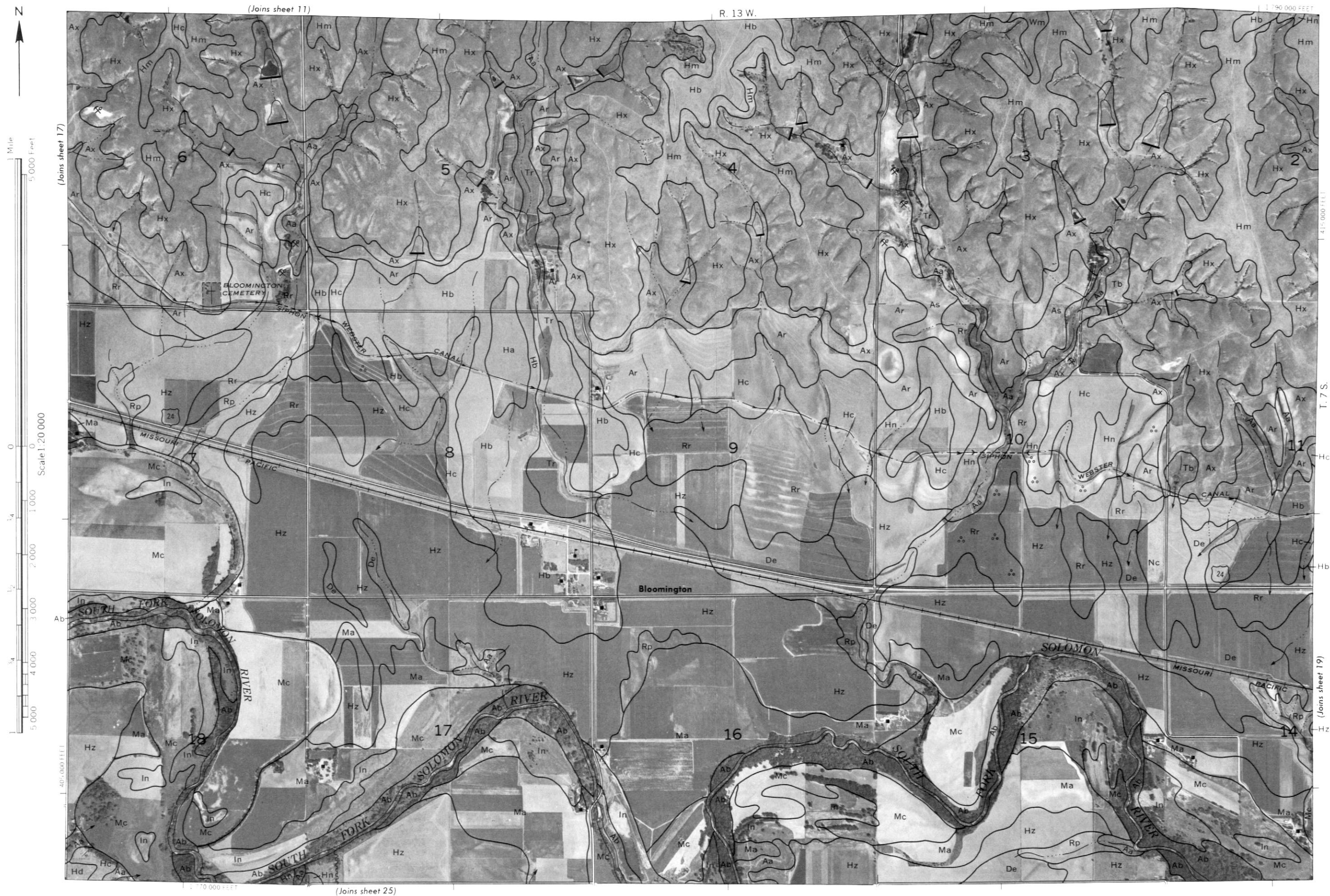
Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.



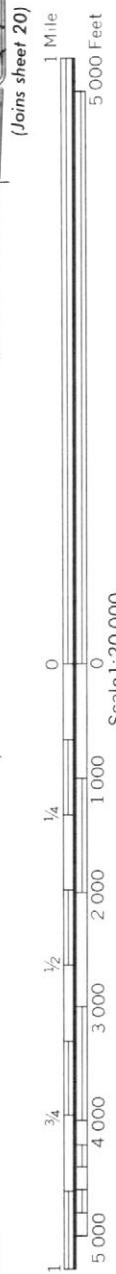






R. 13 W. | R. 12 W.

(Joins sheet 12)



(Joins sheet 20)

405 000 FEET



(Joins sheet 26)

1 810 000 FEET

(Joins sheet 18)

T. 7 S.

4 15 000 FEET

2 1 795 000 FEET

Wm

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.

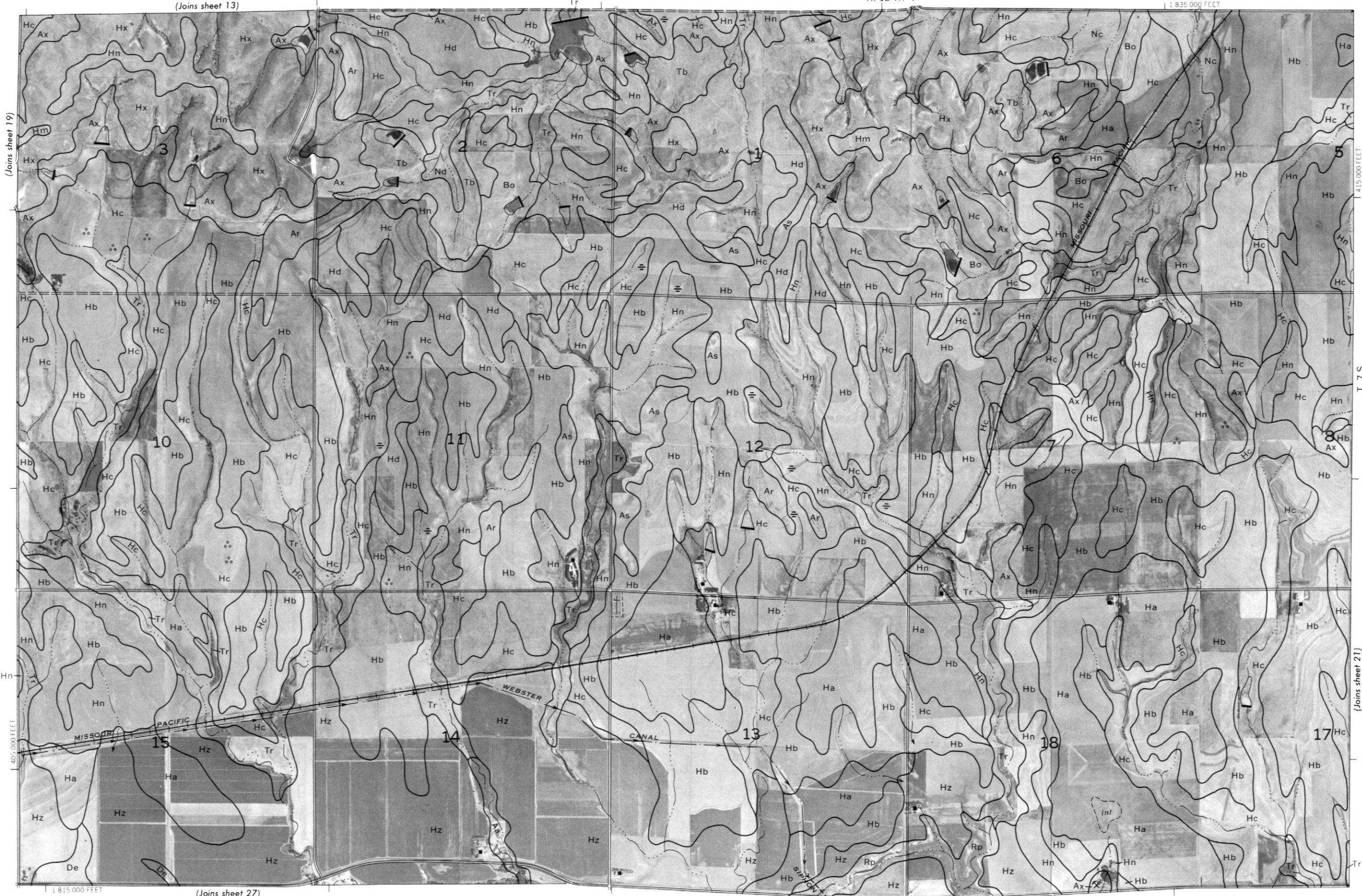
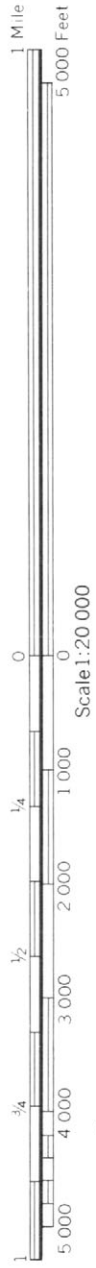




(Joins sheet 13)

R. 12 W. | R. 11 W.

1 835 000 FEET



(Joins sheet 27)

(Joins sheet 21)

Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.





5,000 Feet

Scale 1:20 000

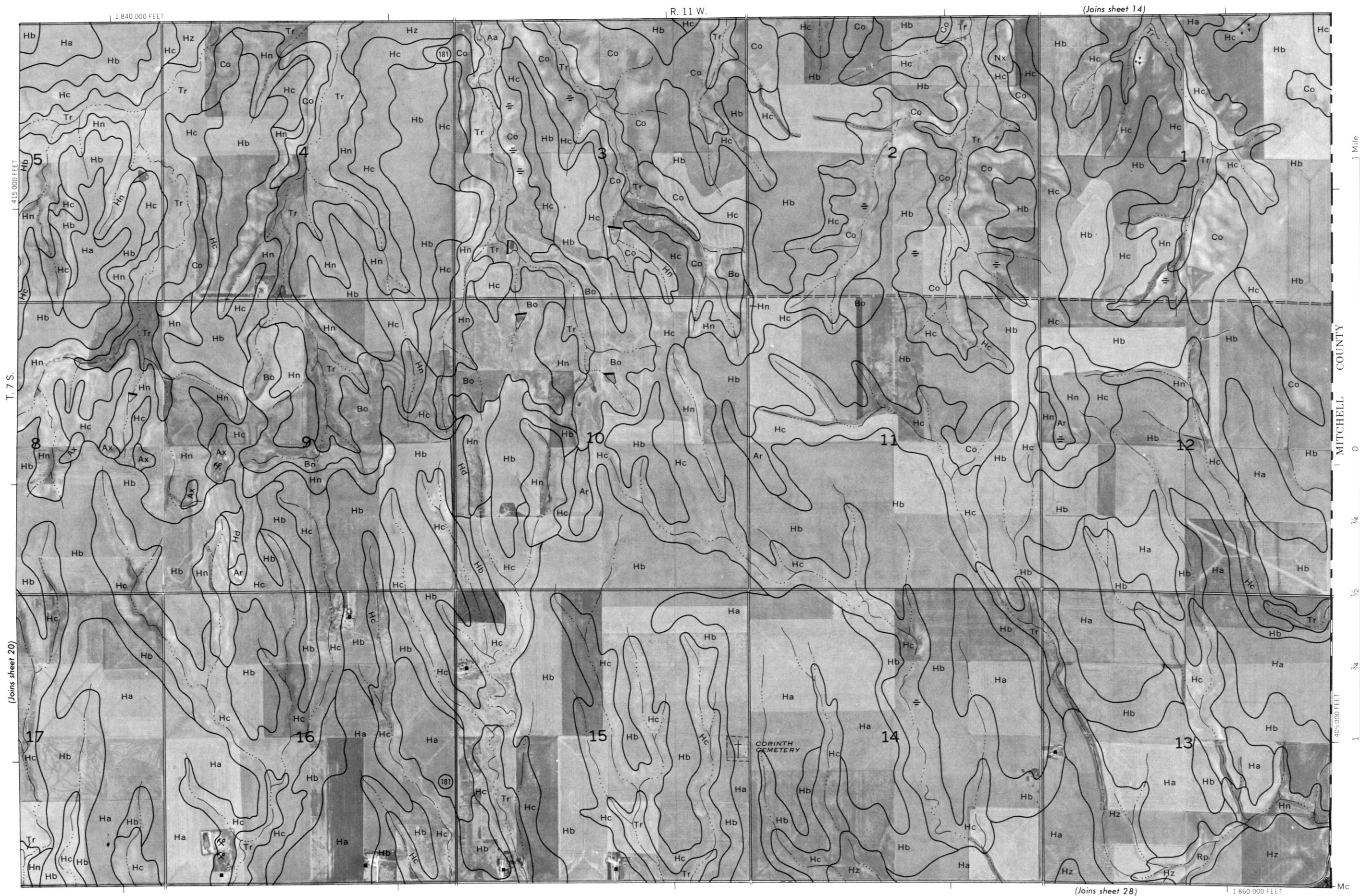
Scale 1:20 000

1

C

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5 000-foot grid ticks are approximate and based on the Kansas coordinate system: north zone.

Land division corners are approximately positioned on this map.

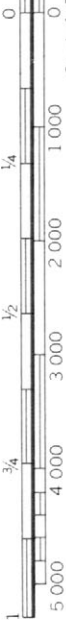






1 Mile  
5 000 Feet

Scale 1:20 000



(Joins sheet 15)

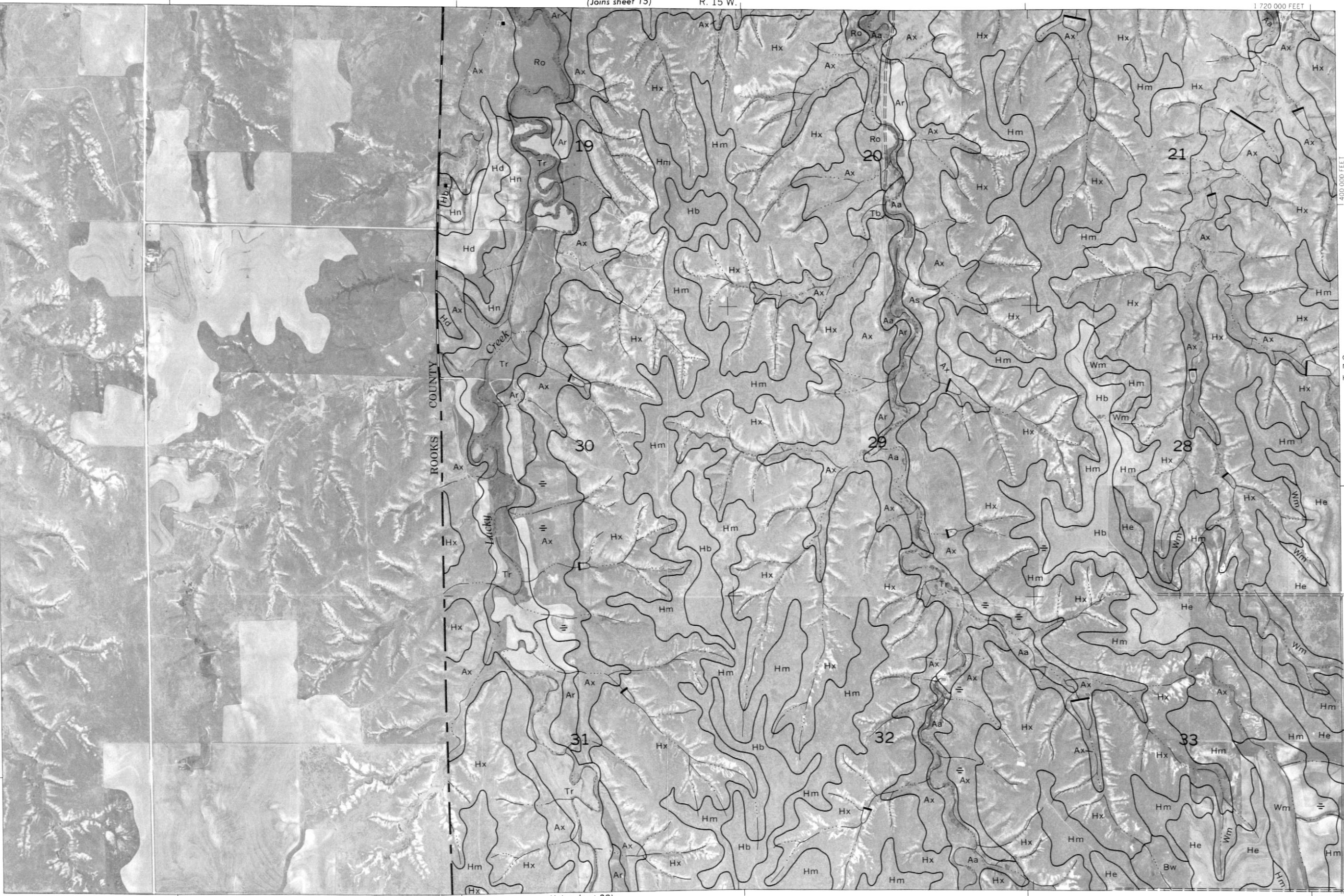
R. 15 W.

1 720 000 FEET

1 400 000 FEET

(Joins sheet 23)

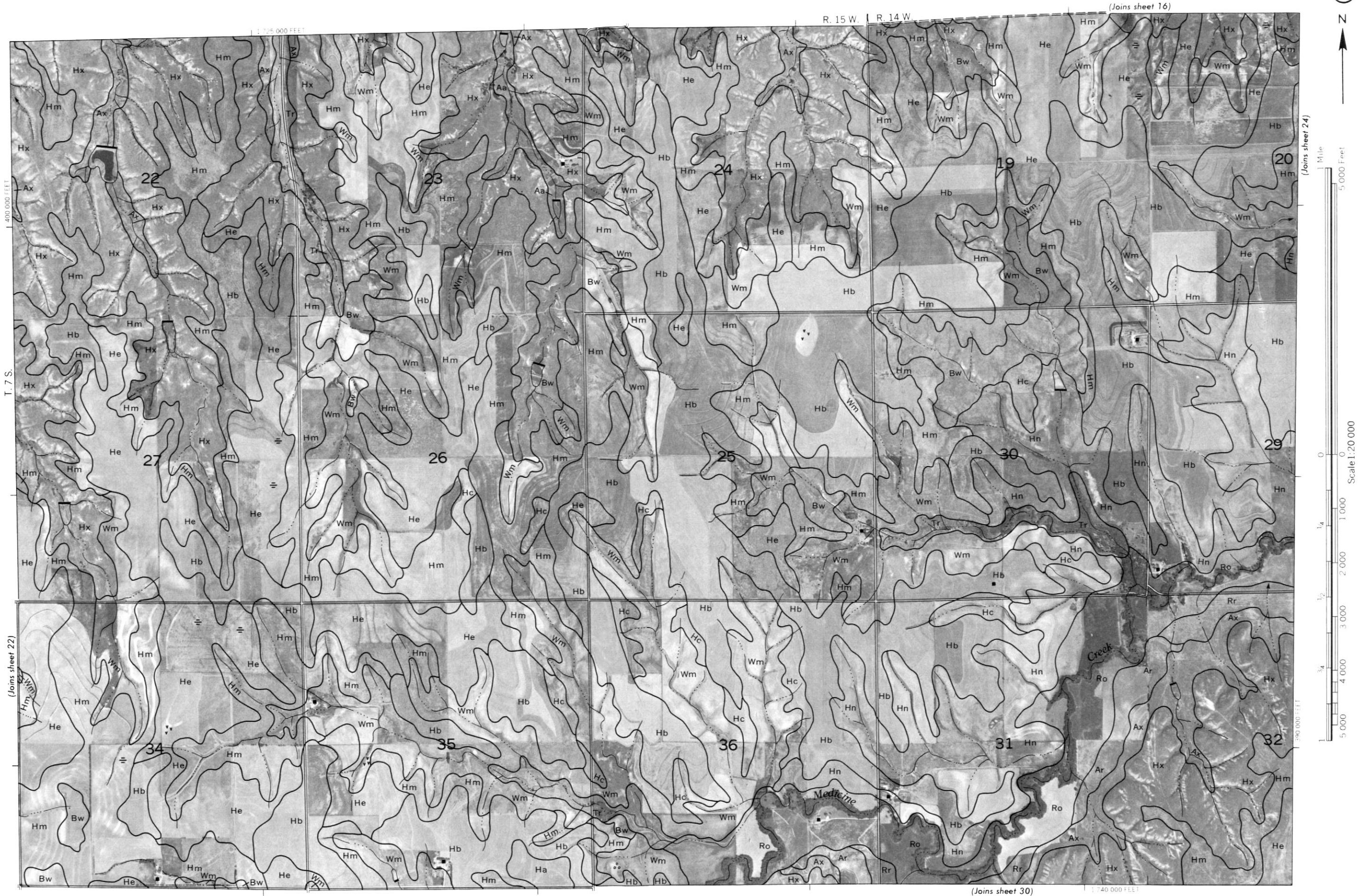
(Joins sheet 29)



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.  
Photobase from 1971 aerial photography. Positions of 5 000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.





(Joins sheet 17)

R. 14 W.

1 765 000 FEET



1 Mile  
5 000 Feet

Scale 1:20 000

0 1 000 2 000 3 000 4 000 5 000  
1/4 1/2 3/4



1 400 000 FEET

T. 7 S.

(Joins sheet 25)

Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5 000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.









(Joins sheet 19)

R. 13 W. | R. 12 W.

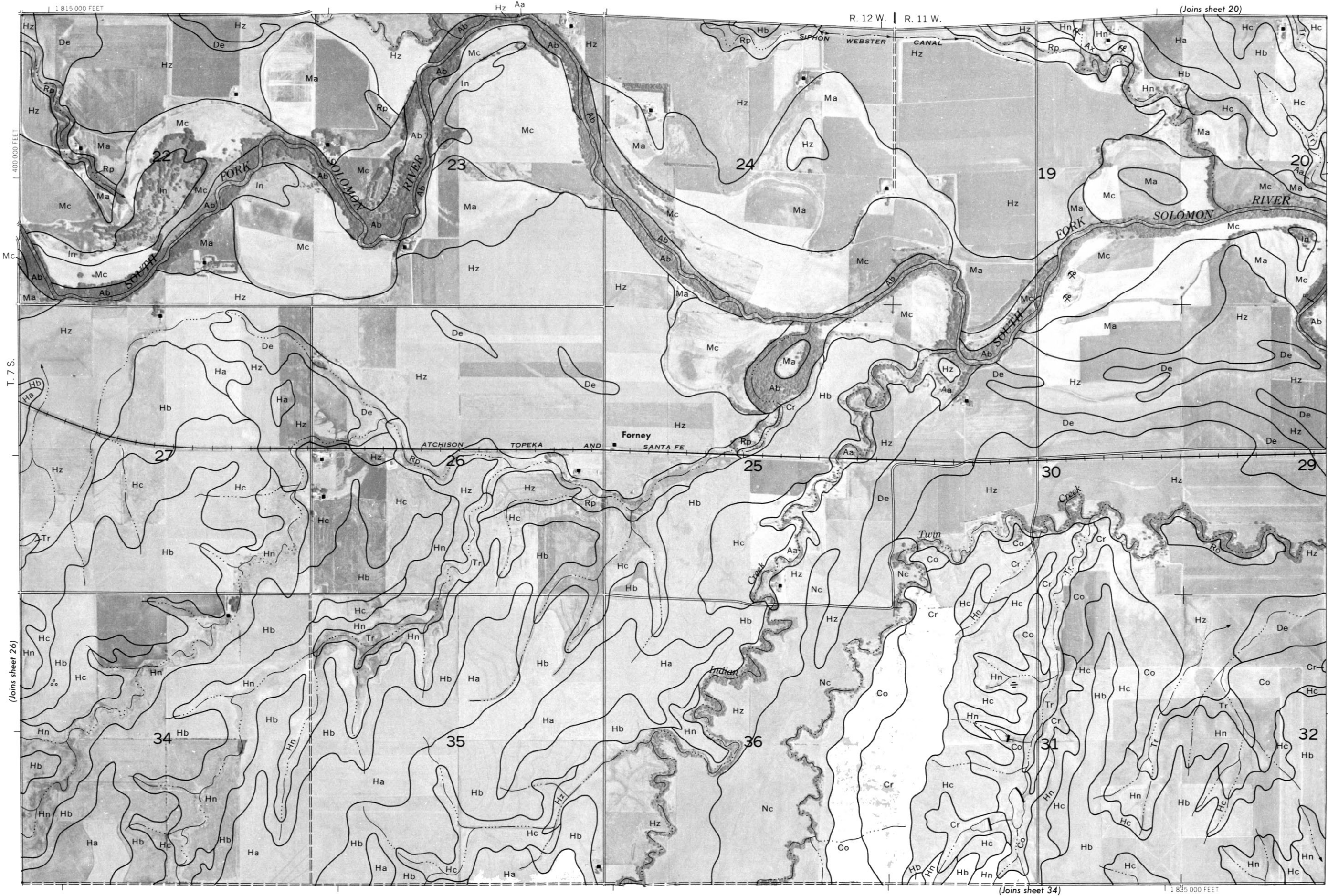
1:810 000 FEET



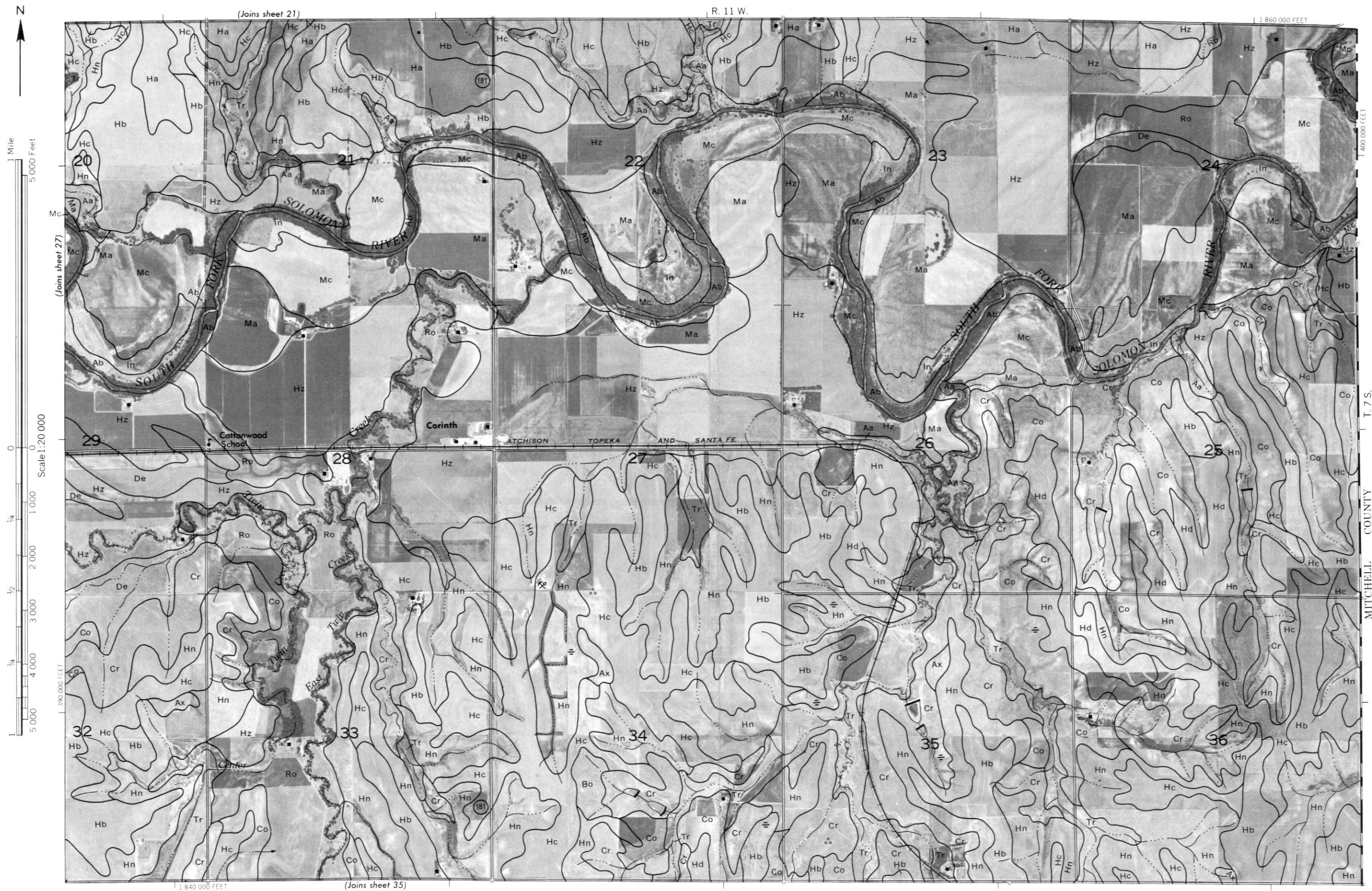
Land decision codes are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid lines are approximate and based on the Kansas coordinate system, north zone.  
This map is a part of a set compiled in 1974 as part of a cooperative project by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.



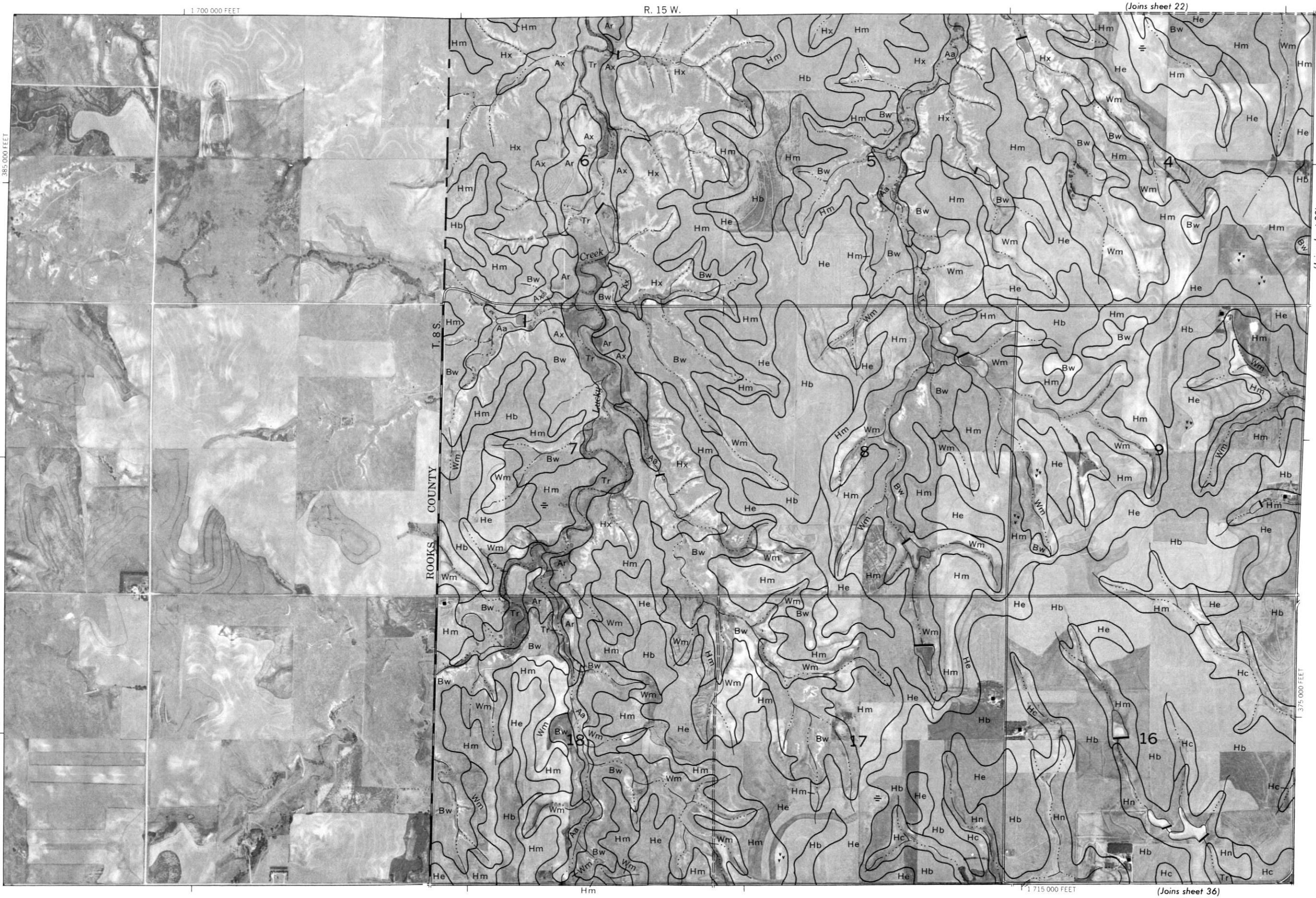




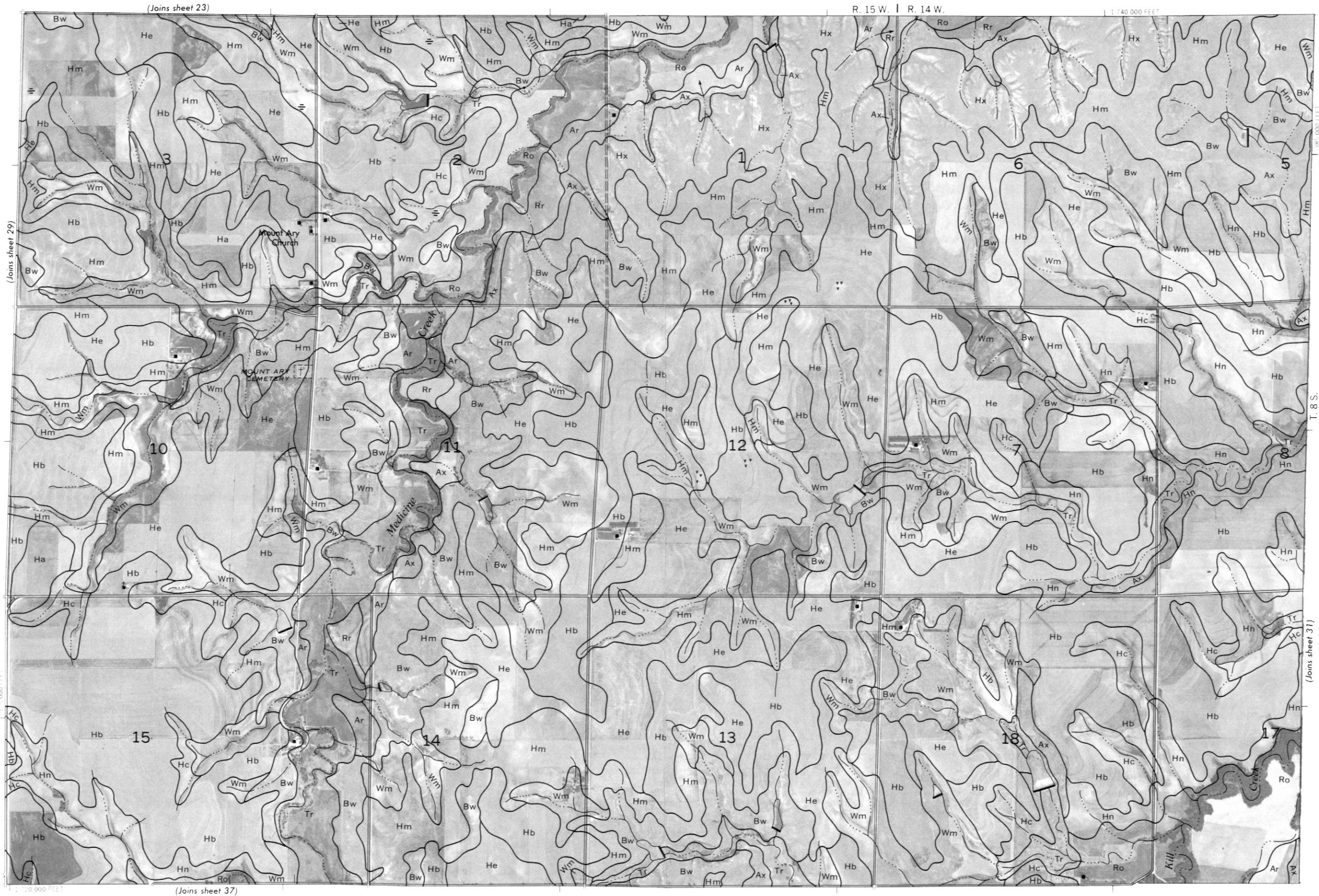
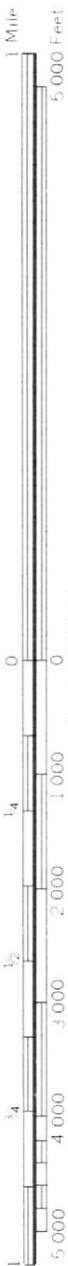
Land division corners are approximately positioned on this map  
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.





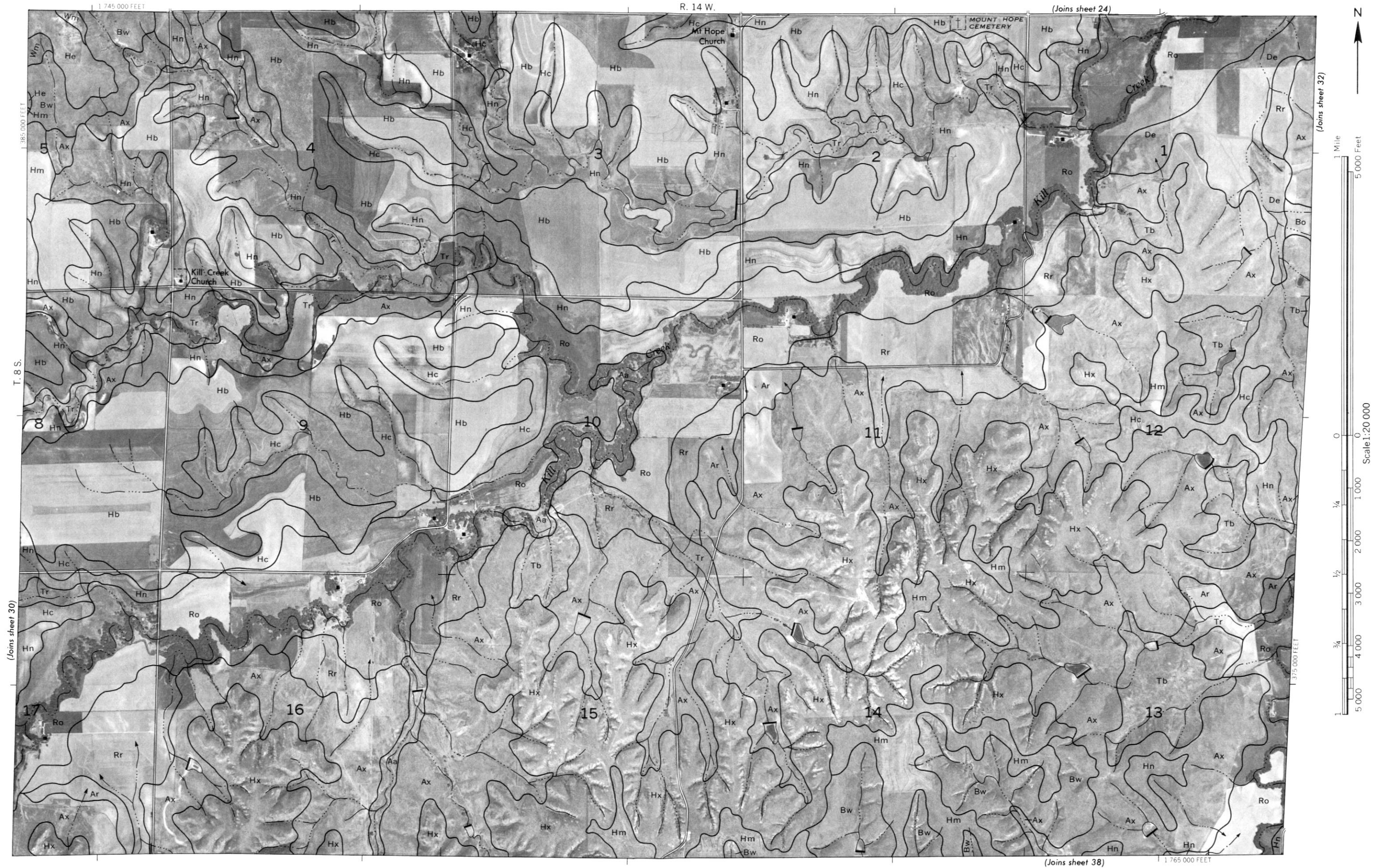


Land divisions shown are approximately positioned on this map.  
Photographs from 1971 aerial photography. Boundaries of 5,000 foot grid lines are approximate and based on the Kansas coordinate system north zone.  
This map is one of a set compiled in 1974 as part of a survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

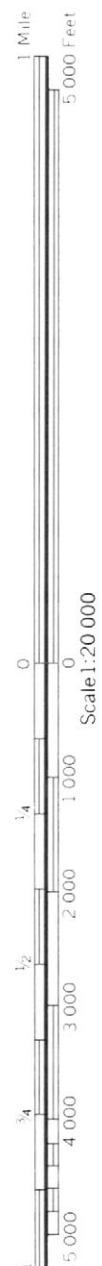


OSBORNE COUNTY, KANSAS NO. 31

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.







R. 13 W.

1790 000 FEET

(Joins sheet 25)

(Joins sheet 31)

T. 8 S.

(Joins sheet 33)

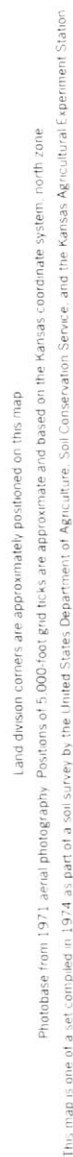
(Joins sheet 39)

Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service and the Kansas Agricultural Experiment Station.









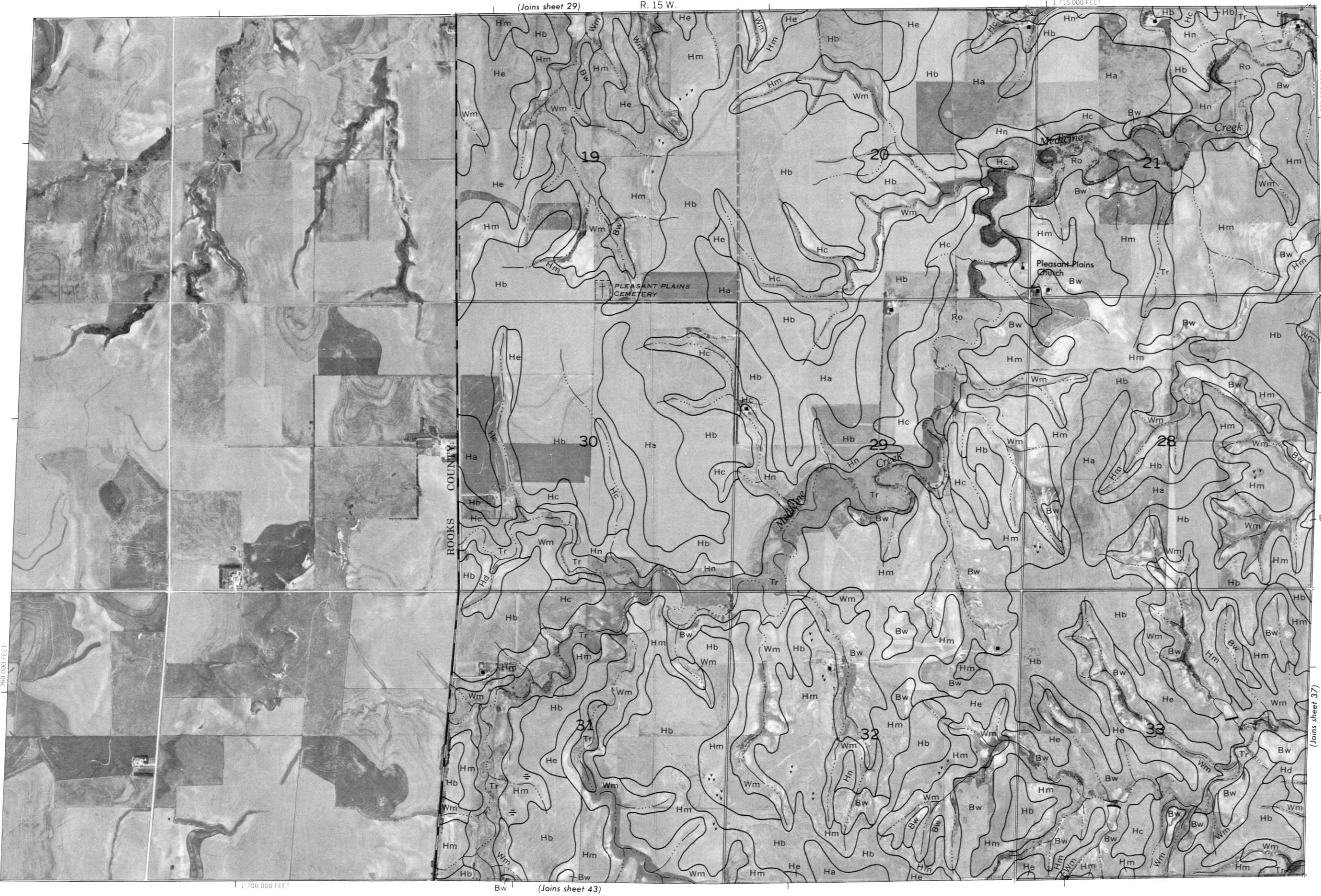
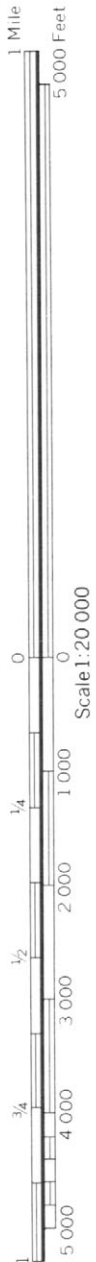




This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.

OSBORNE COUNTY, KANSAS NO. 35





Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

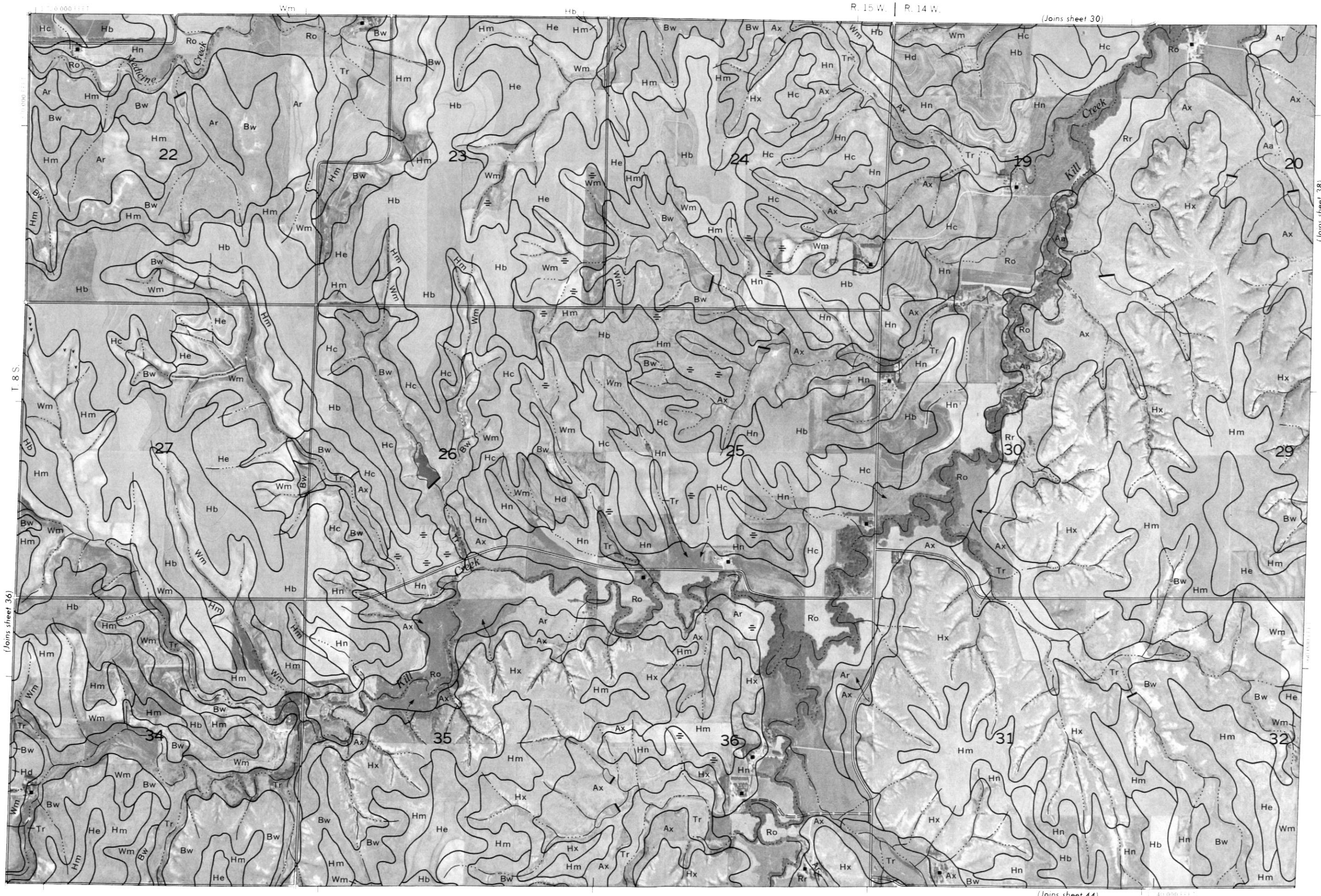




(Joins sheet 38)

Scale 1:20,000

(Joins sheet 44)



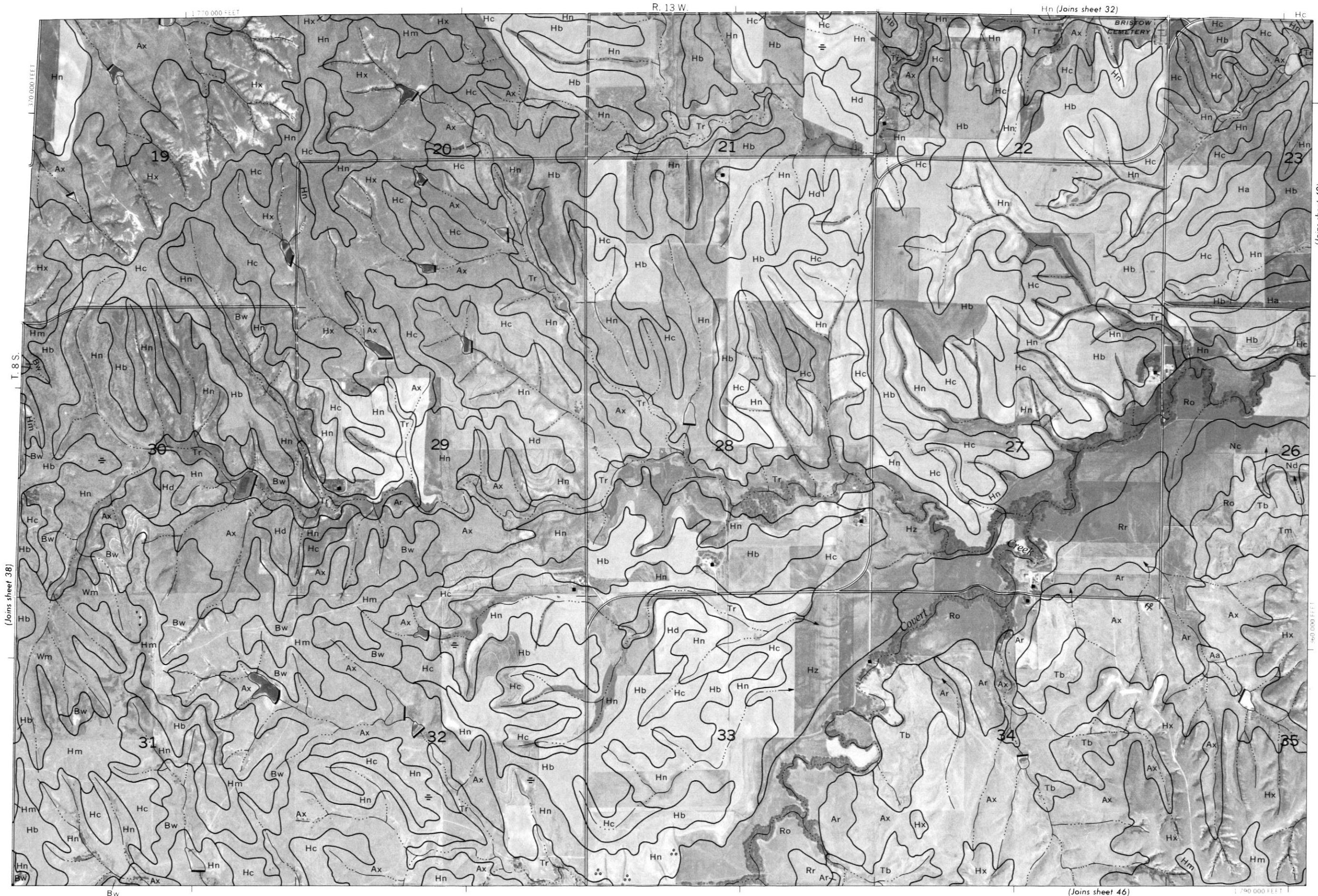
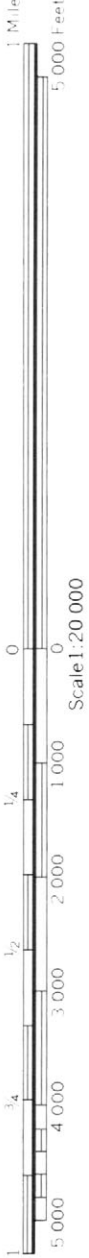
This map was prepared by the United States Department of Agriculture, Soil Conservation Service, and the National Agricultural Experiment Station, Ames, Iowa. The map is based on a 1:25,000 scale aerial photograph. The map is published by the United States Government Printing Office, Washington, D.C. 20540.





Land division corners are approximately positioned on this map. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

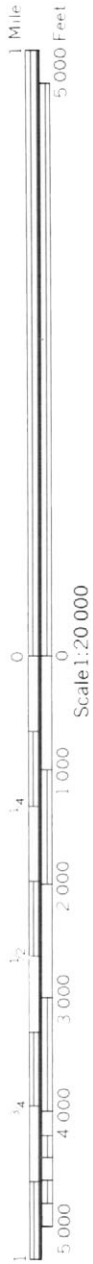




OSBORNE COUNTY, KANSAS NO. 39

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photographs from 1971 aerial photography. Positions of 1:50,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.





R. 13 W. | R. 12 W.

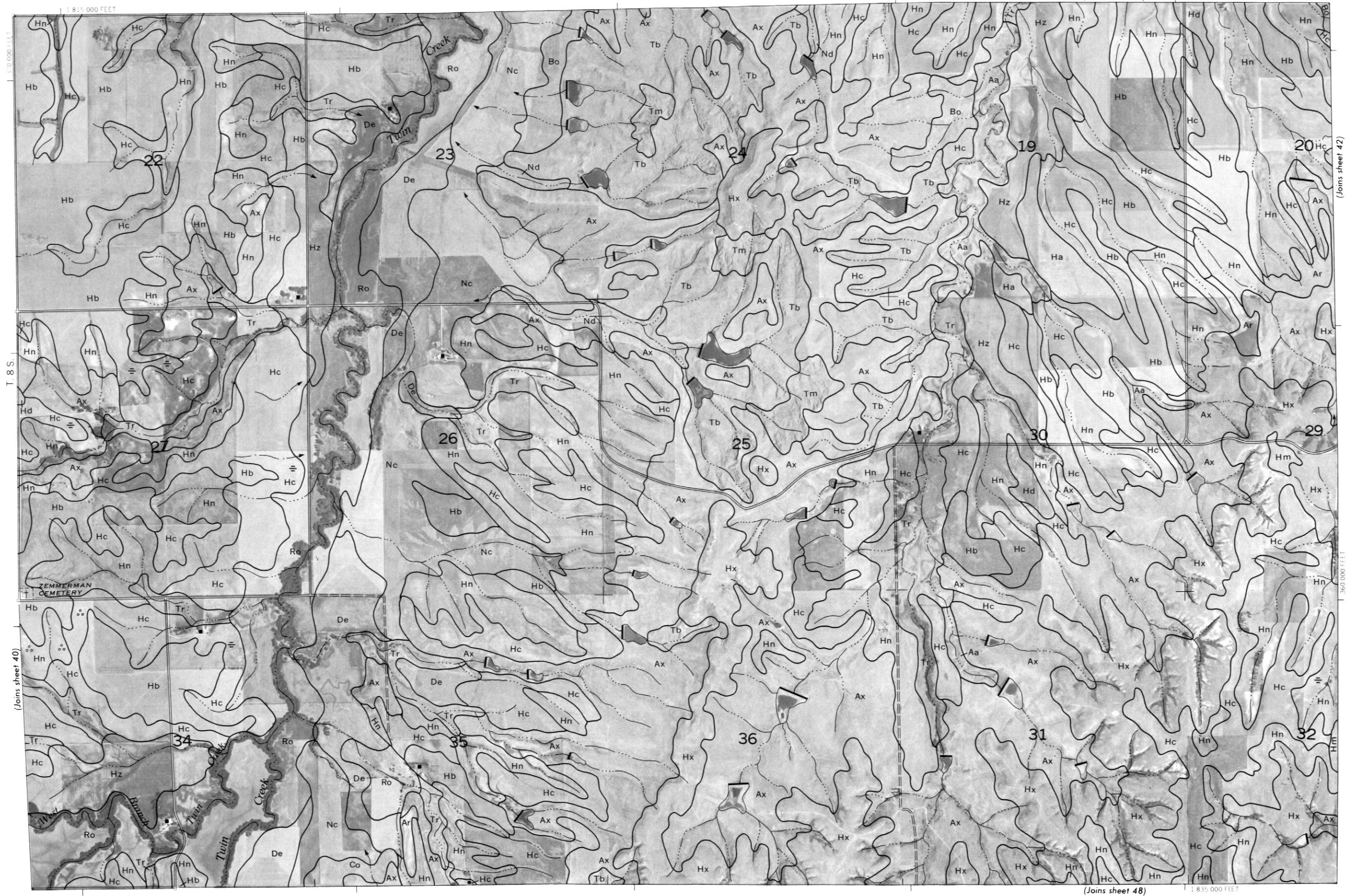
1810 000 FEET



This map is a reproduction of the original map, which was prepared by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. The map is based on aerial photography taken in 1941. The map is a reproduction of the original map, which was prepared by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. The map is based on aerial photography taken in 1941.



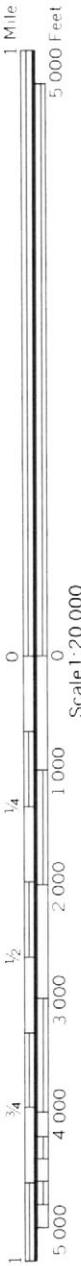
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.











Scale 1:20 000

(Joins sheet 44)

345,000 FEET

Hc

(Joins sheet 36)

R. 15 W.

1 700 000 FEET



(Joins sheet 50)

1 715 000 FEET

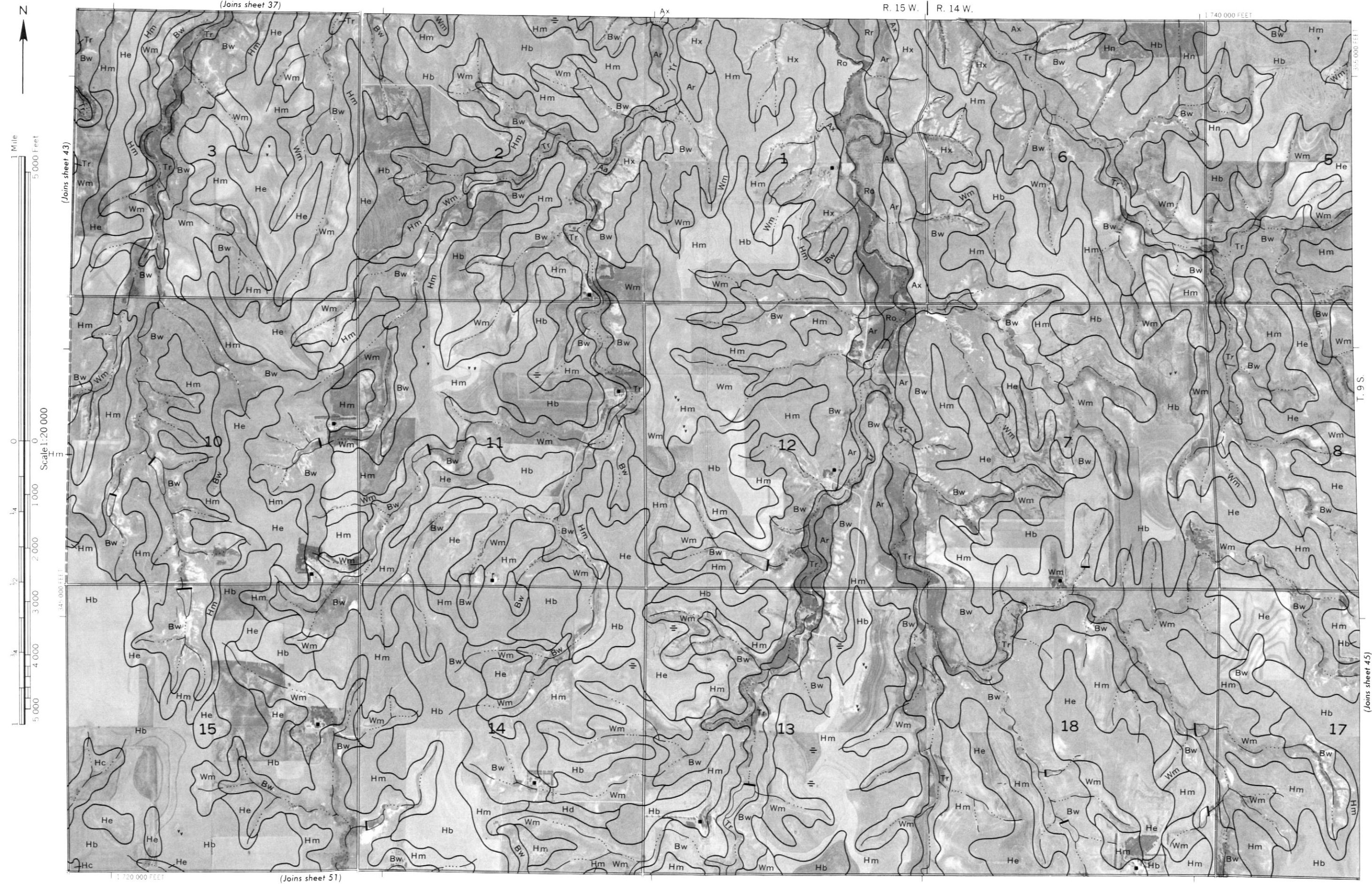
ROOKS COUNTY

T. 9 S.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photographs from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.

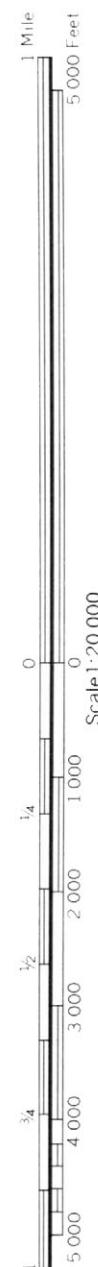
OSBORNE COUNTY, KANSAS NO. 43





Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid lines are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.





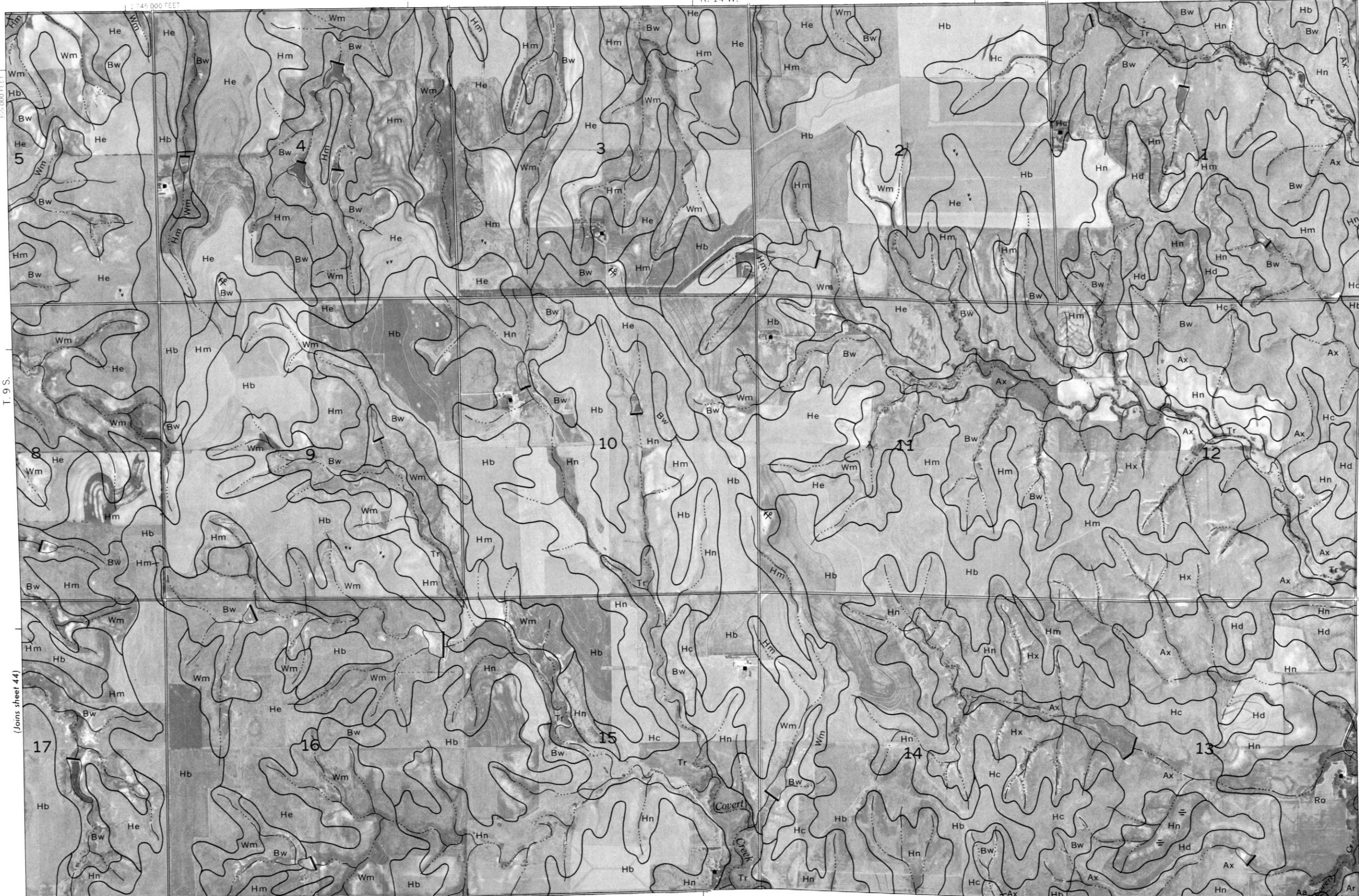
(Joins sheet 46)

345,000 FEET

(Joins sheet 38)

R. 14 W.

1 745 000 FEET



(Joins sheet 52)

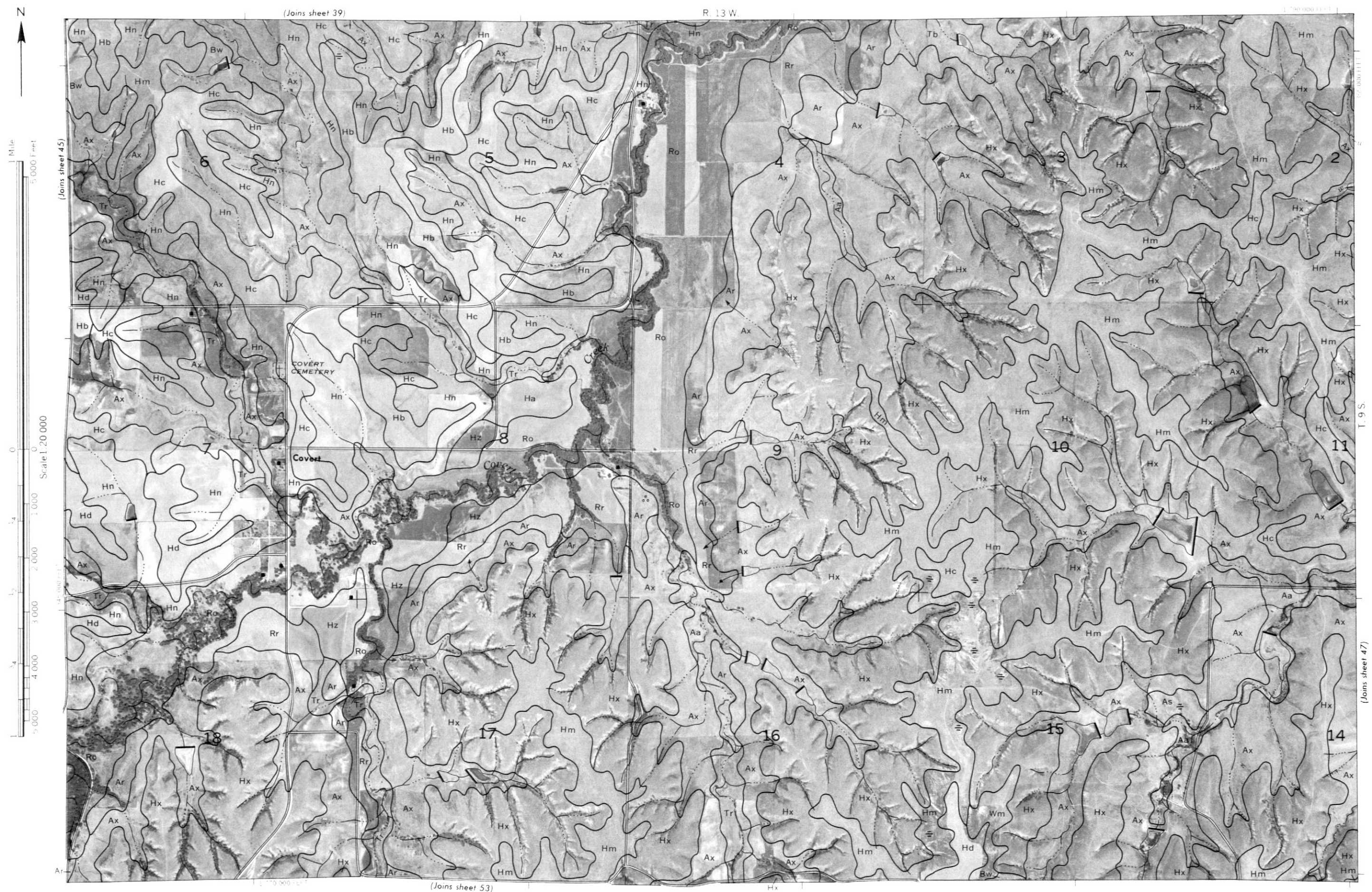
1 765 000 FEET

T. 9 S.

(Joins sheet 44)

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photographs. Positions of 5,000 foot grid lines are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.

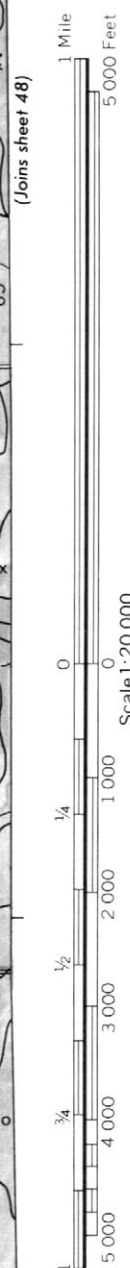




and design. colors are approximate, not shown on this map.  
Produced from 1971 aerial photography. Elevation of 5,000 feet and below are approximate and based on the Kansas Geological Survey map.  
The map is a part of a series of maps of the United States, Department of Agriculture, Soil Conservation Service, and the National Agricultural Experiment Station.



(Joins sheet 40)



OSBORNE COUNTY, KANSAS NO. 47





(Joins sheet 41)



(Joins sheet 47)

T. 9 S.

(Joins sheet 49)

(Joins sheet 55)

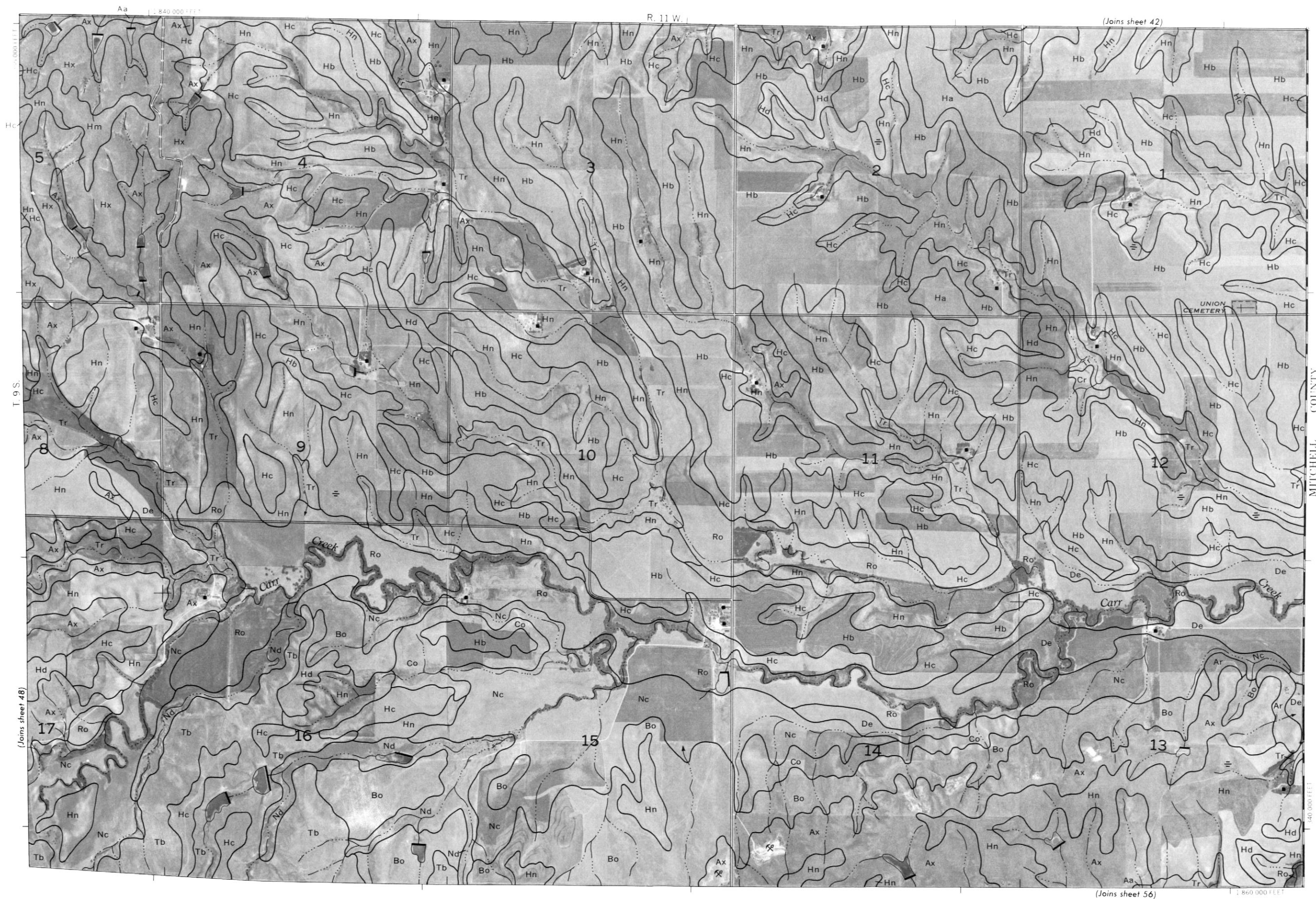


Scale 1:20 000

Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photographs from 1971 aerial photography. Positions of 5,000 foot grid lines are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately as shown on this map.

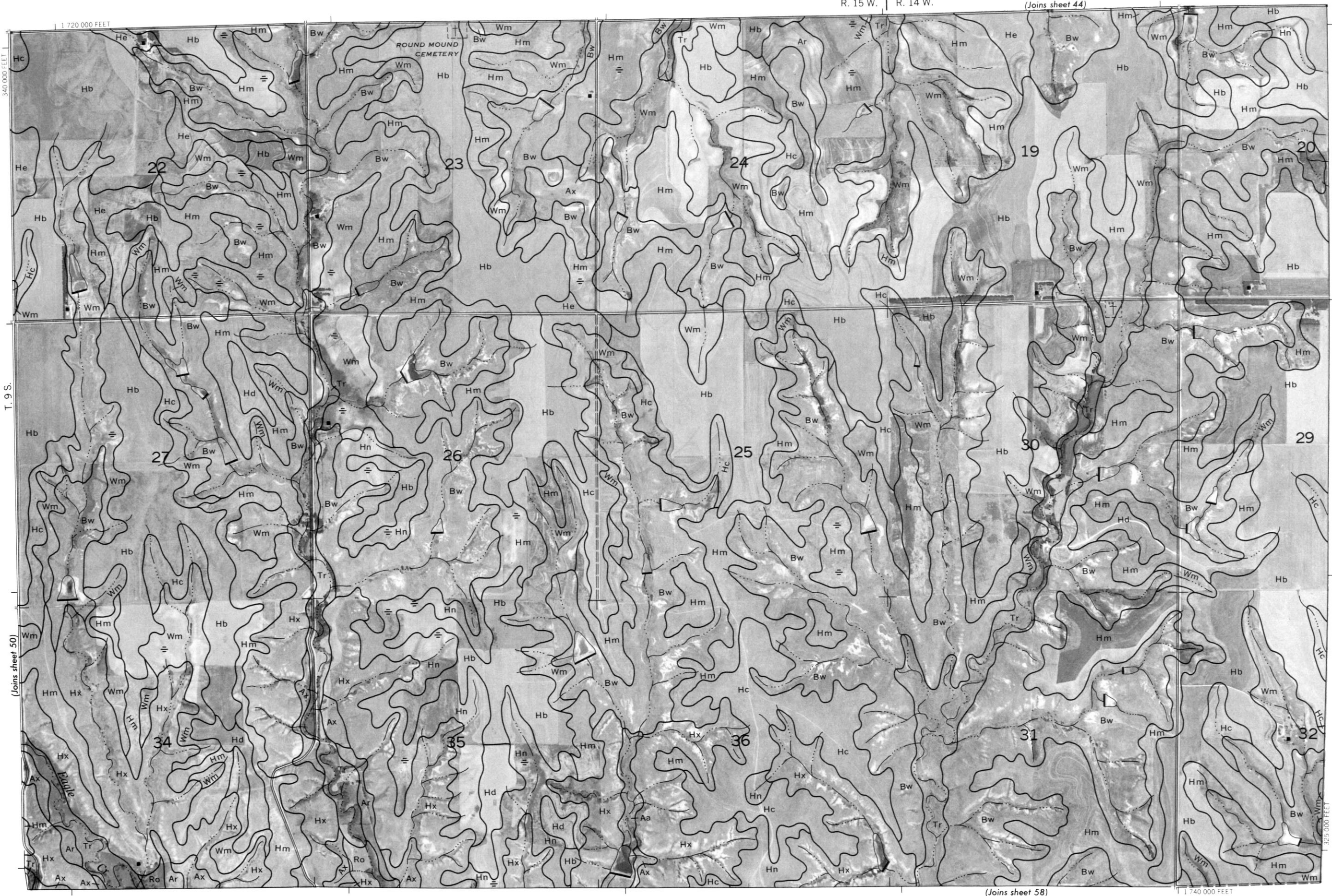








This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station  
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone  
Land division corners are approximately positioned on this map.



(Joins sheet 52)

1 Mile  
5 000 Feet

0 1 000 2 000 3 000 4 000 5 000

Scale 1:20 000

1 3/4 1/2 1/4 0 0 1 000 2 000 3 000 4 000 5 000

Scale 1:20 000

(Joins sheet 58)

1 740 000 FEET

T. 9 S.

(Joins sheet 50)

340 000 FEET

1 720 000 FEET

325 000 FEET



(Joins sheet 45)

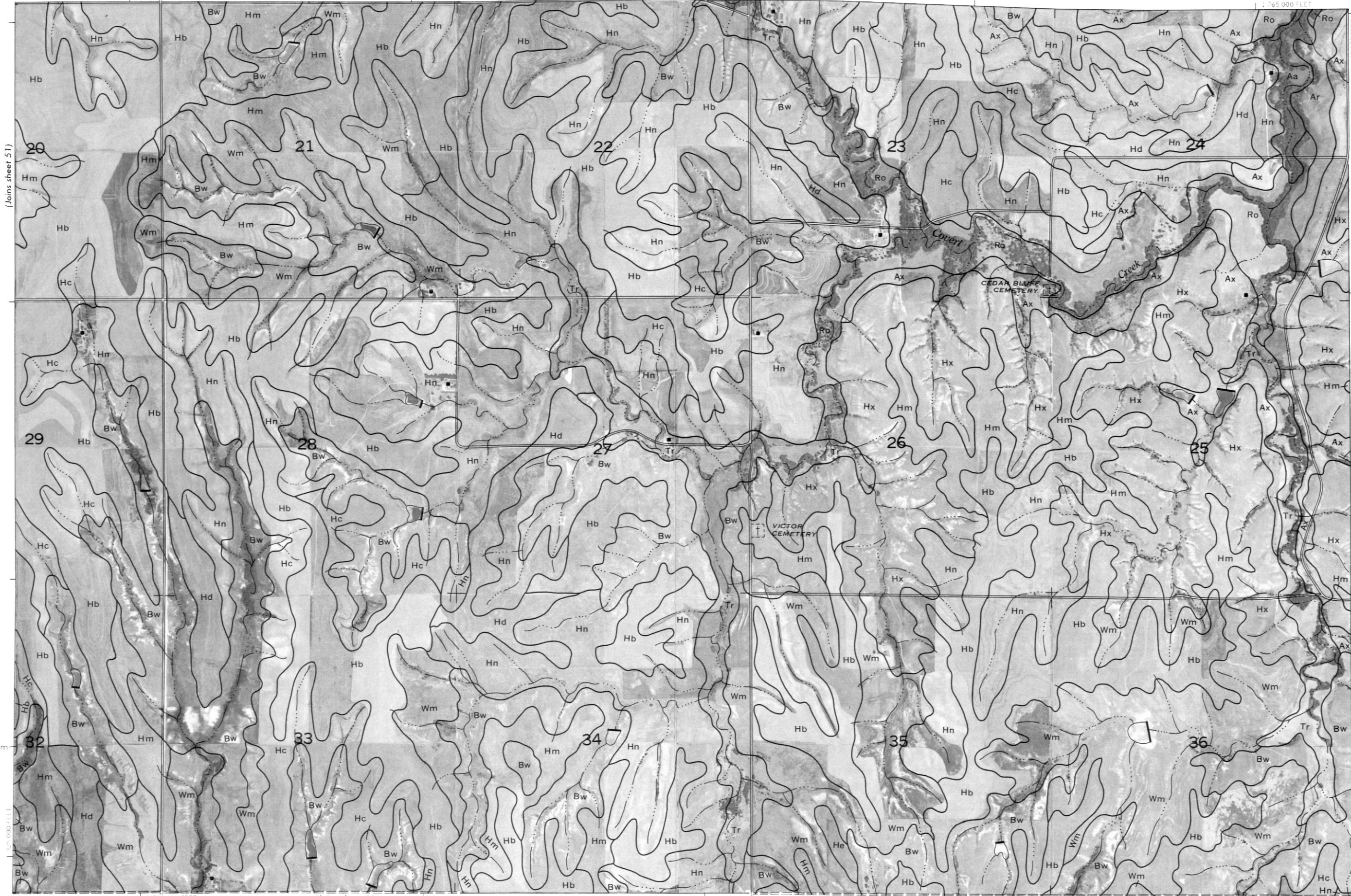
R. 14 W.

1:765 000 FEET



1 Mile  
5 000 Feet

Scale 1:20 000



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system north zone.  
Land division corners are approximately positioned on this map.



(Joins sheet 46)

Z

(Joins sheet 54)

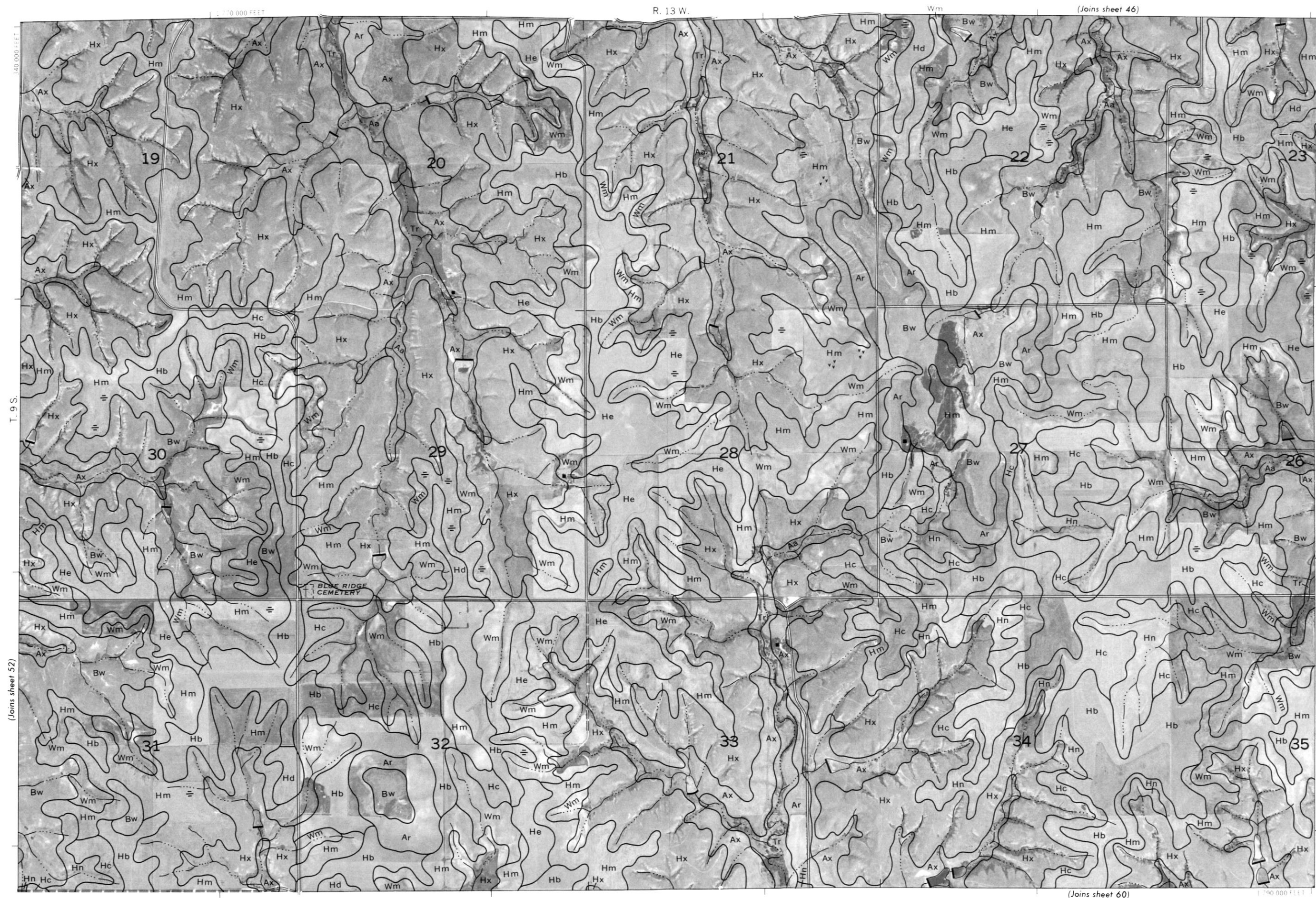
1 Mile  
5,000 Feet

0  
Scale 1:20 000

Category	14	17	34	50
No	~1000	~1000	~1000	~1000
Small	~1000	~1000	~1000	~1000
Medium	~1000	~1000	~1000	~1000
Big	~1000	~1000	~1000	~1000
Very big	~1000	~1000	~1000	~1000

325 000 441

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land use/cover corners are approximately positioned on this map.





(Joins sheet 47)

R. 13 W. T. 9 S.

1:81,000 FEET



(Joins sheet 53)

Scale 1:20,000



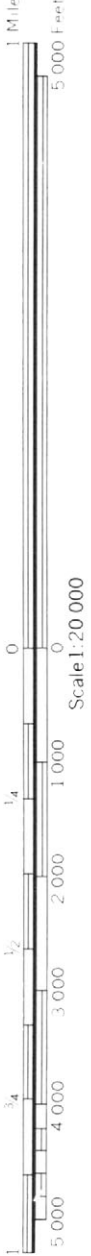
(Joins sheet 55)

(Joins sheet 61)

1:81,000 FEET

Land division corners are approximately positioned on this map. Photobase from 1971 aerial photography. Positions of 5,000 foot grid lines are approximate and based on the Kansas coordinate system north zone. This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.





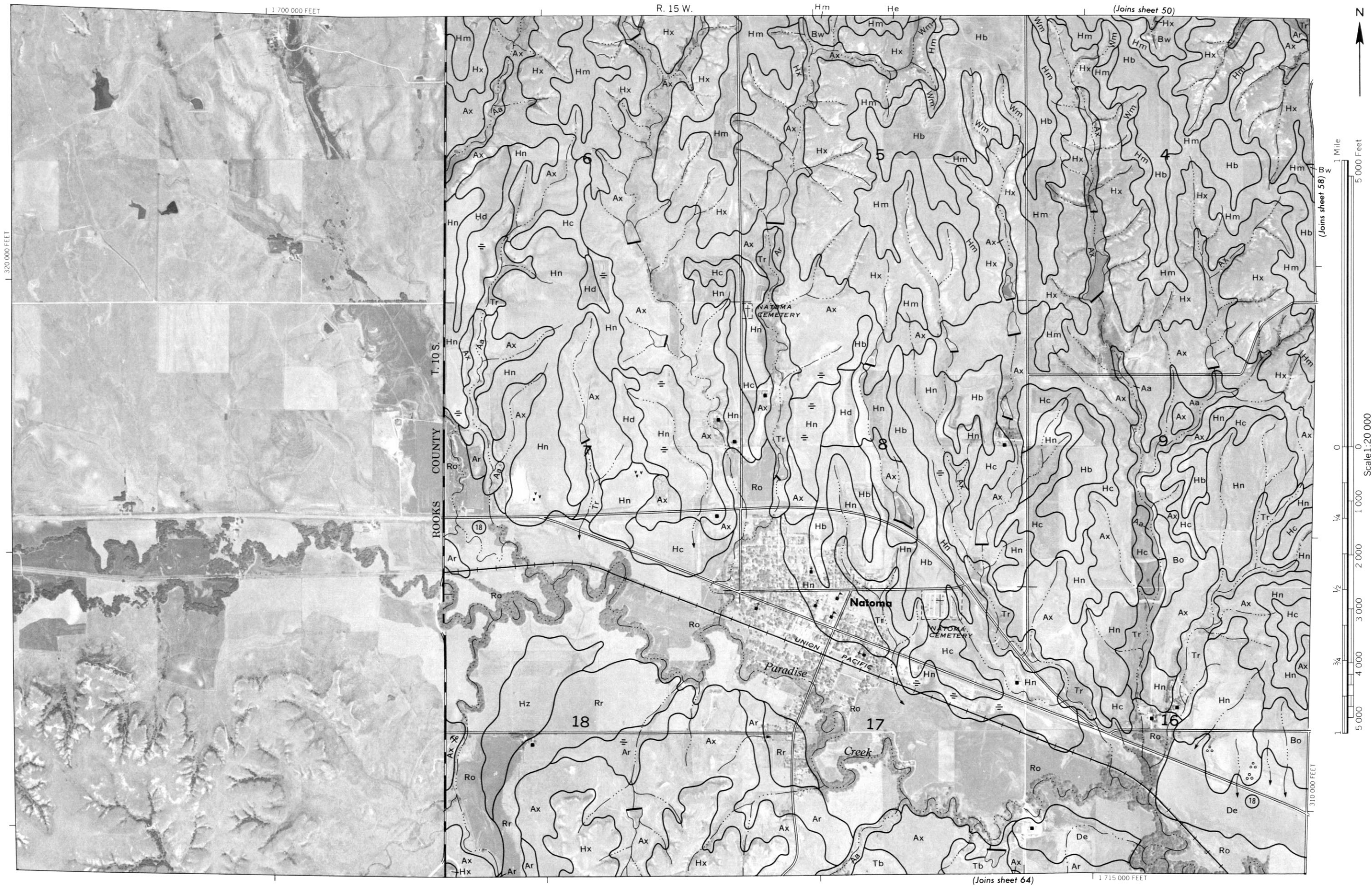




Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

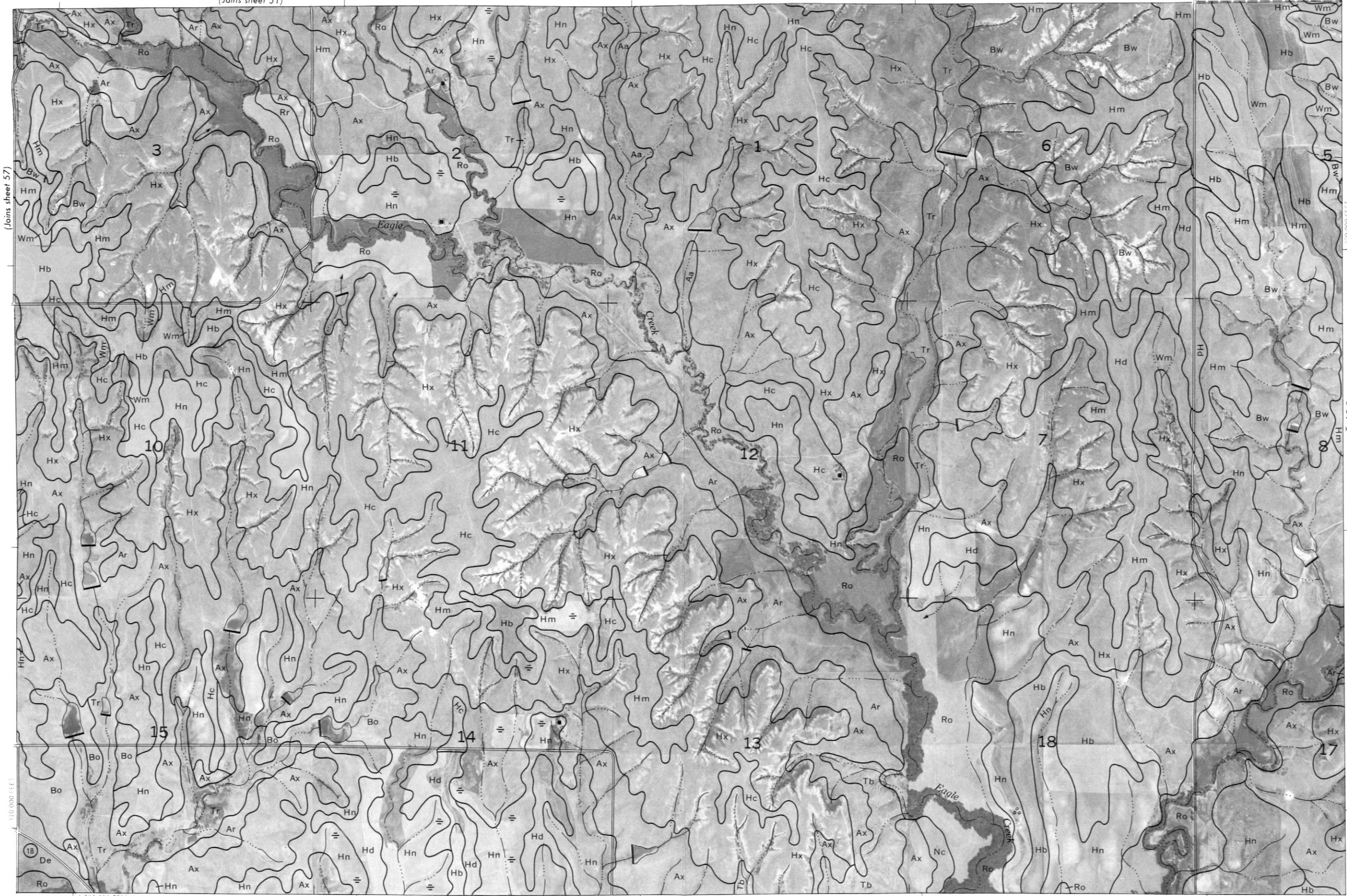


This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone. Land division corners are approximately positioned on this map.





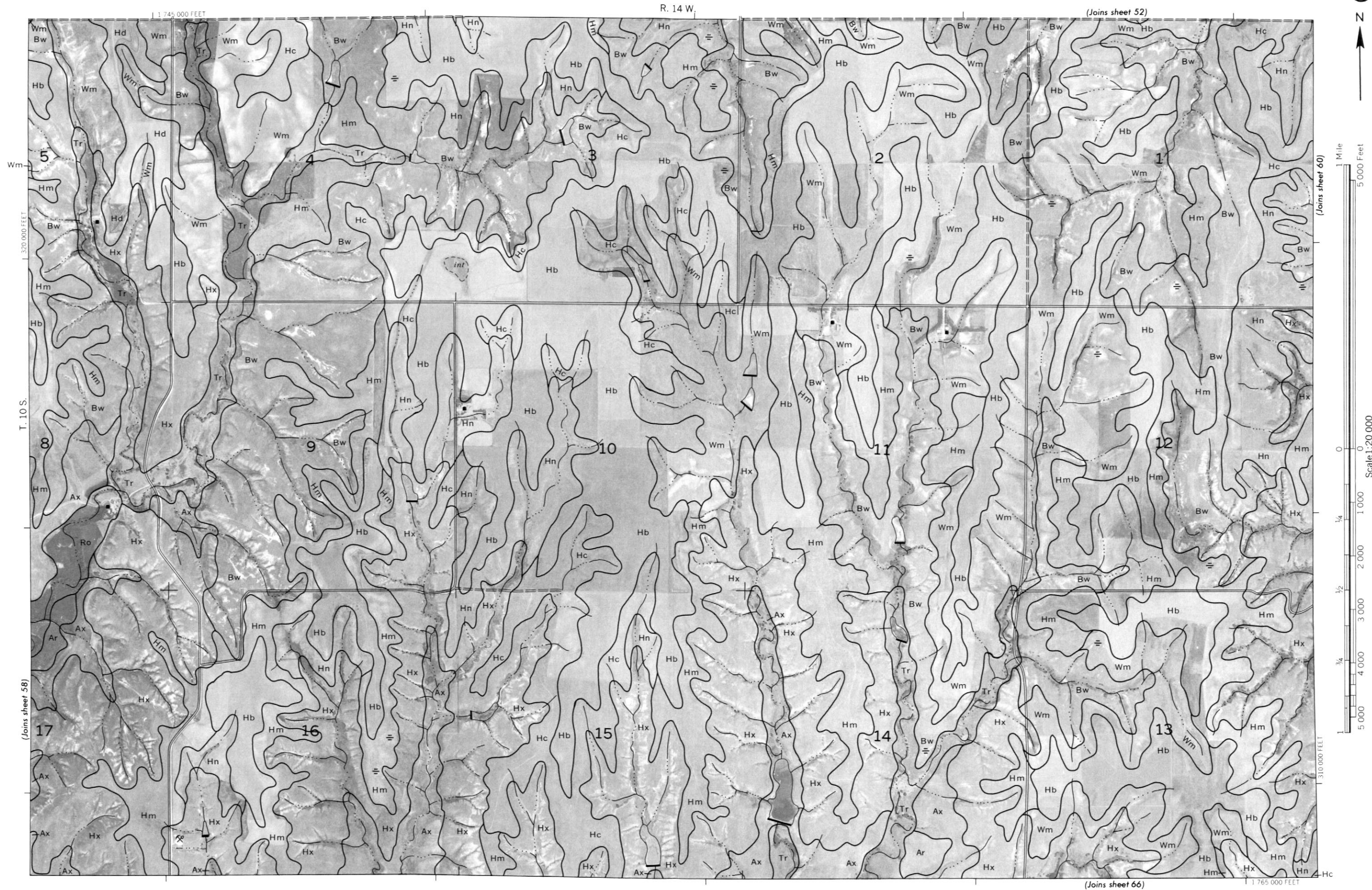
(Joins sheet 51)



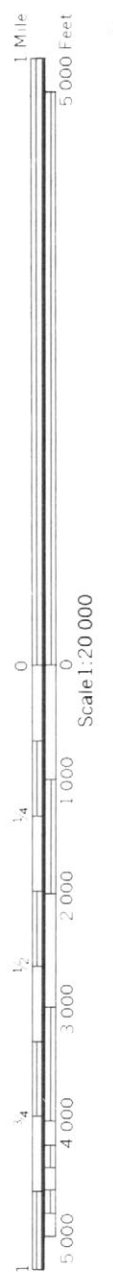
Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000-foot grid lines are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



Land division corners are approximately positioned on this map







Land designations are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000 foot grid lines are approximate and based on the Kansas coordinate system, north zone.  
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



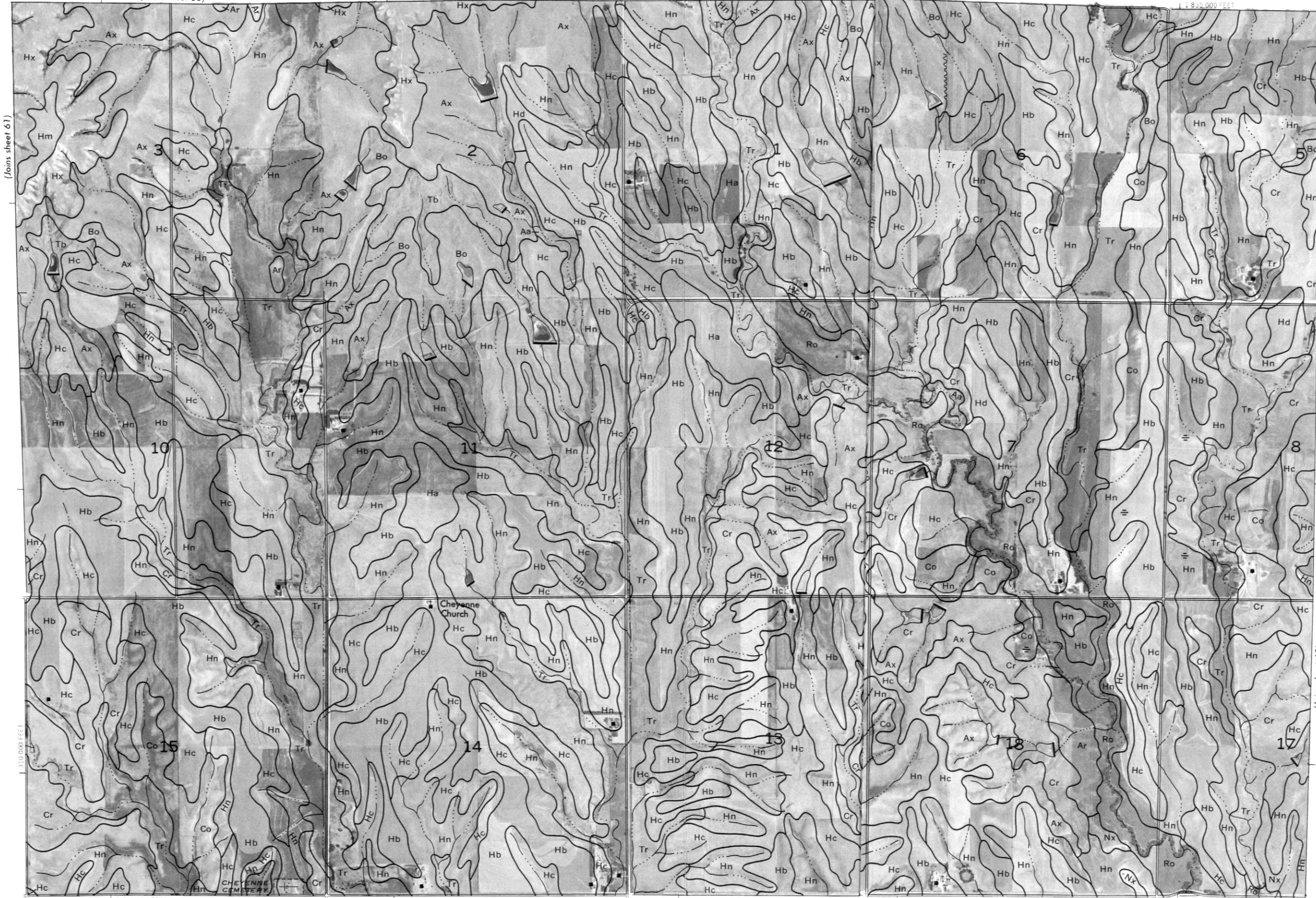
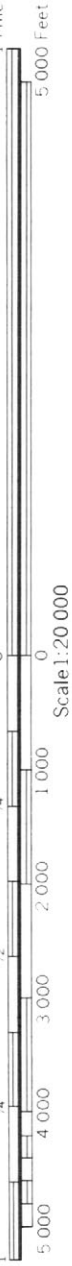




R. 11 W.

(Joins sheet 55)

1:835,000 FEET



Land division corners are approximately positioned on this map. Probable from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system north zone. This map is one of a set compiled in 1974 as part of a soil survey, by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



R. 11 W.

(Joins sheet 56)



1 Mile  
5 000 Feet

0 1 000 2 000 3 000 4 000 5 000

Scale 1:20 000

1 3/4 1/2 1/4

5 000 4 000 3 000 2 000 1 000

310 000 FEET

1 860 000 FEET

(Joins sheet 70)

1 840 000 FEET

(Joins sheet 62)

T. 10 S.

320 000 FEET

1 840 000 FEET

1 860 000 FEET

1 880 000 FEET

1 900 000 FEET

1 920 000 FEET

1 940 000 FEET

1 960 000 FEET

1 980 000 FEET

2 000 000 FEET

2 020 000 FEET

2 040 000 FEET

2 060 000 FEET

2 080 000 FEET

2 100 000 FEET

2 120 000 FEET

2 140 000 FEET

2 160 000 FEET

2 180 000 FEET

2 200 000 FEET

2 220 000 FEET

2 240 000 FEET

2 260 000 FEET

2 280 000 FEET

2 300 000 FEET

2 320 000 FEET

2 340 000 FEET

2 360 000 FEET

2 380 000 FEET

2 400 000 FEET

2 420 000 FEET

2 440 000 FEET

2 460 000 FEET

2 480 000 FEET

2 500 000 FEET

2 520 000 FEET

2 540 000 FEET

2 560 000 FEET

2 580 000 FEET

2 600 000 FEET

2 620 000 FEET

2 640 000 FEET

2 660 000 FEET

2 680 000 FEET

2 700 000 FEET

2 720 000 FEET

2 740 000 FEET

2 760 000 FEET

2 780 000 FEET

2 800 000 FEET

2 820 000 FEET

2 840 000 FEET

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2 880 000 FEET

2 900 000 FEET

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3 080 000 FEET

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3 160 000 FEET

3 180 000 FEET

3 200 000 FEET

3 220 000 FEET

3 240 000 FEET

3 260 000 FEET

3 280 000 FEET

3 300 000 FEET

3 320 000 FEET

3 340 000 FEET

3 360 000 FEET

3 380 000 FEET

3 400 000 FEET

3 420 000 FEET

3 440 000 FEET

3 460 000 FEET

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4 080 000 FEET

4 100 000 FEET

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4 140 000 FEET

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4 200 000 FEET

4 220 000 FEET

4 240 000 FEET

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4 360 000 FEET

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6 460 000 FEET

6 480 000 FEET

6 500 000 FEET

6 520 000 FEET

6 540 000 FEET

6 560 000 FEET

6 580 000 FEET

6 600 000 FEET

6 620 000 FEET

6 640 000 FEET

6 660 000 FEET

6 680 000 FEET

6 700 000 FEET

6 720 000 FEET

6 740 000 FEET

6 760 000 FEET

6 780 000 FEET

6 800 000 FEET

6 820 000 FEET

6 840 000 FEET

6 860 000 FEET

6 880 000 FEET

6 900 000 FEET

6 920 000 FEET

6 940 000 FEET

6 960 000 FEET

6 980 000 FEET

7 000 000 FEET

7 020 000 FEET

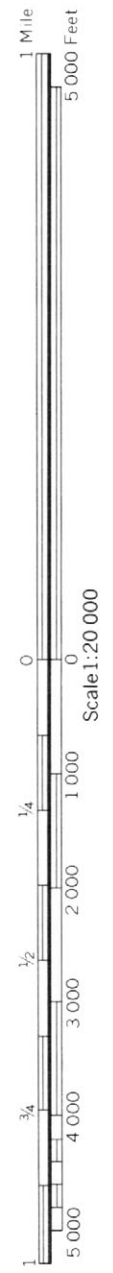
7 040 000 FEET

7 060 000 FEET

7 080 000 FEET

7 100 000 FEET

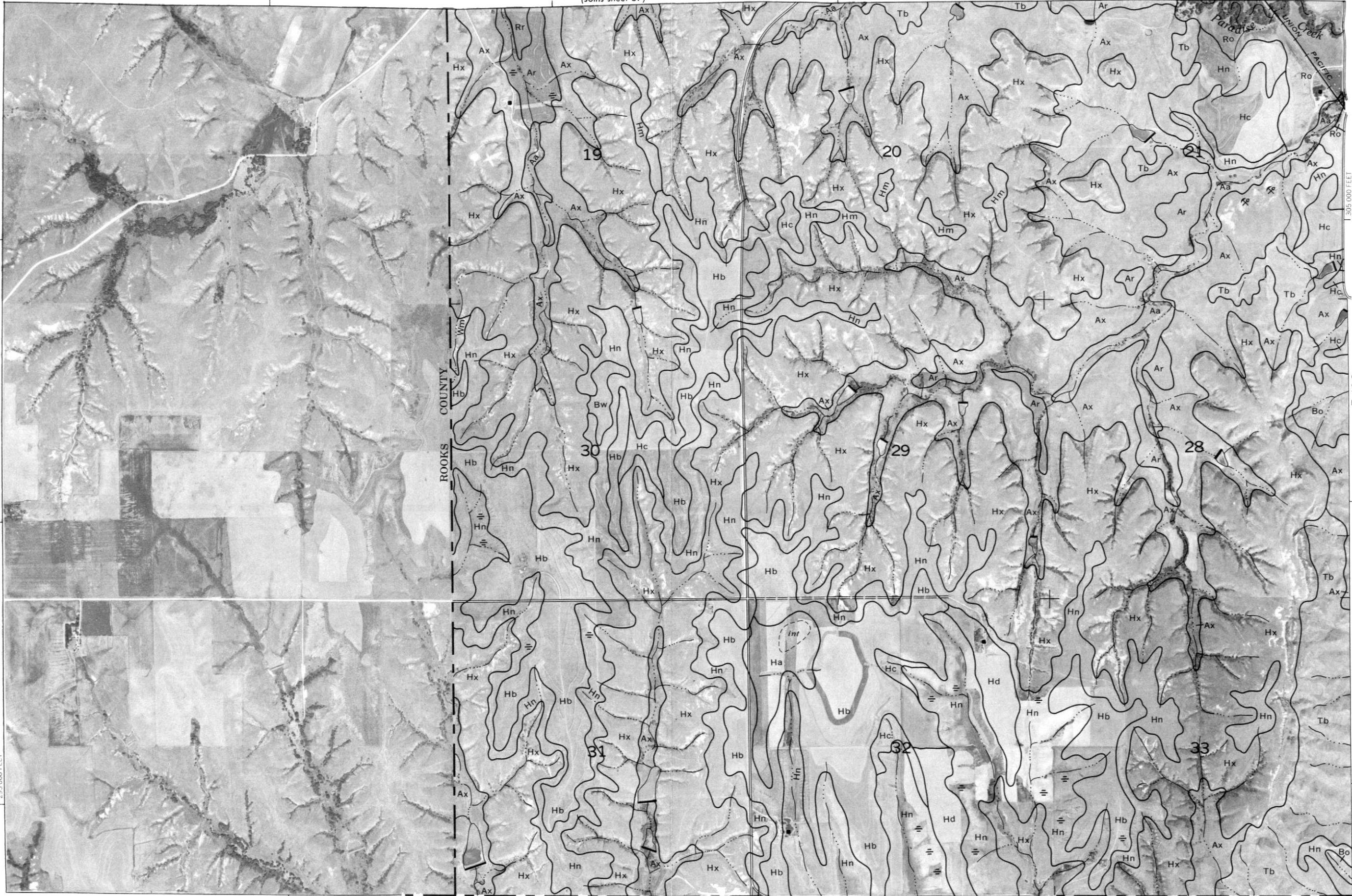




(Joins sheet 57)

R. 15 W.

1 715 000 FEET



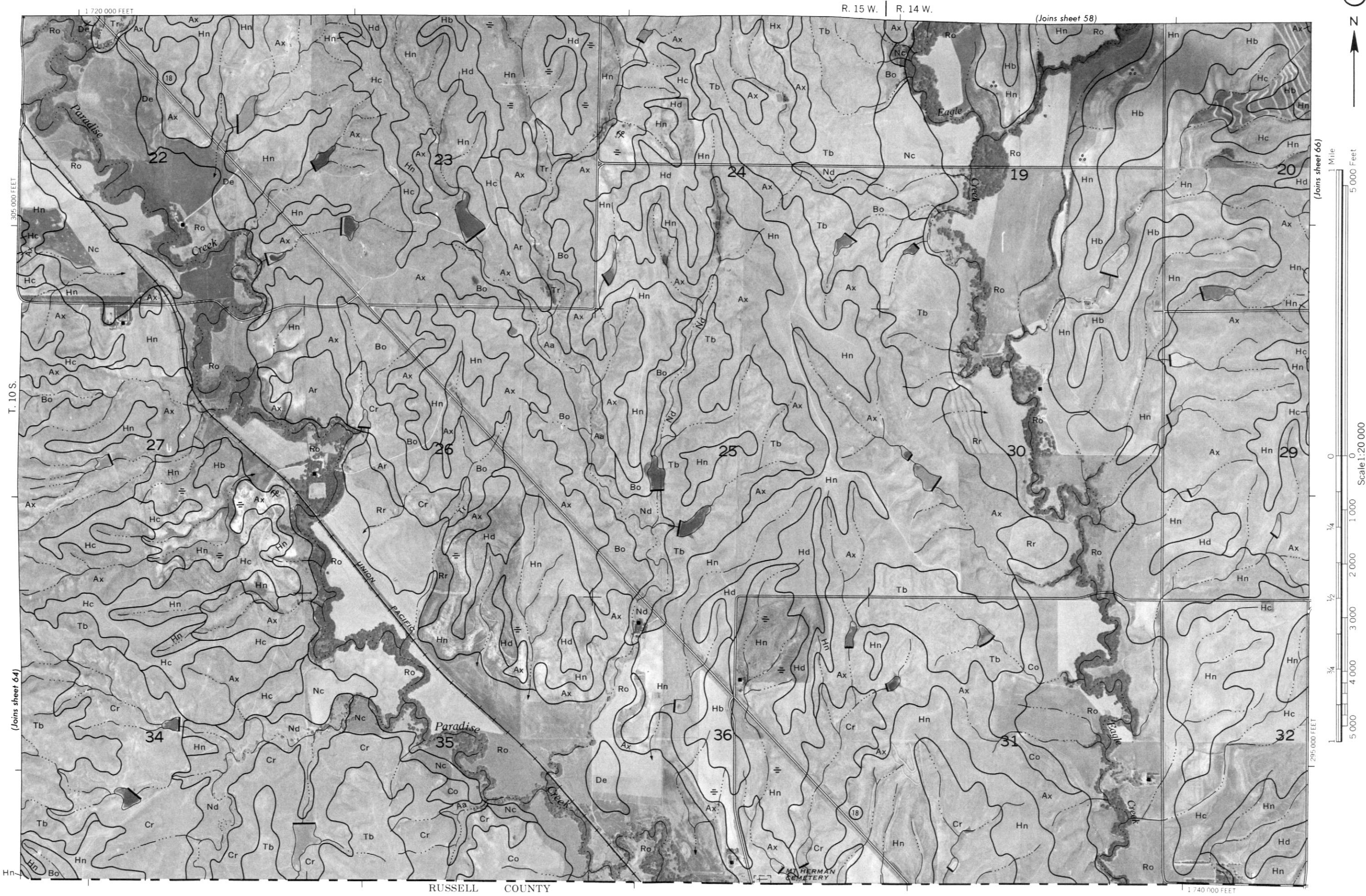
(Joins sheet 65)

T. 10 S.

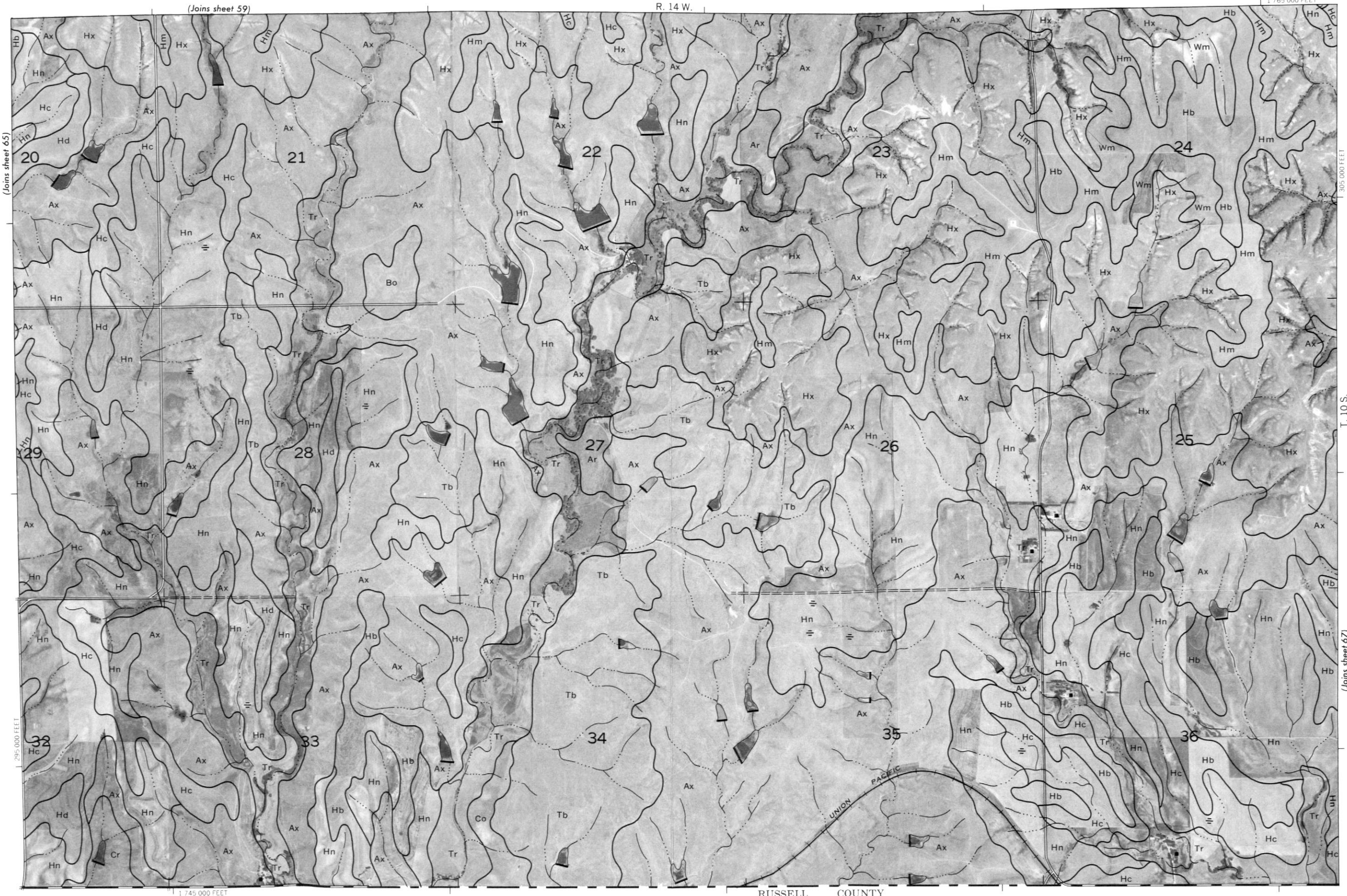
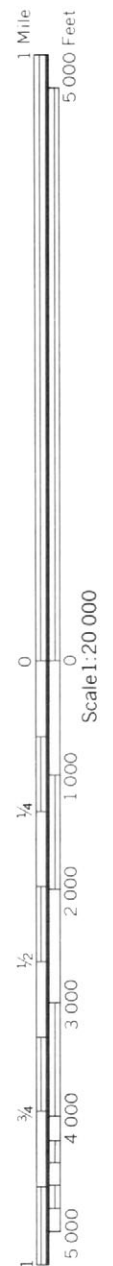
Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
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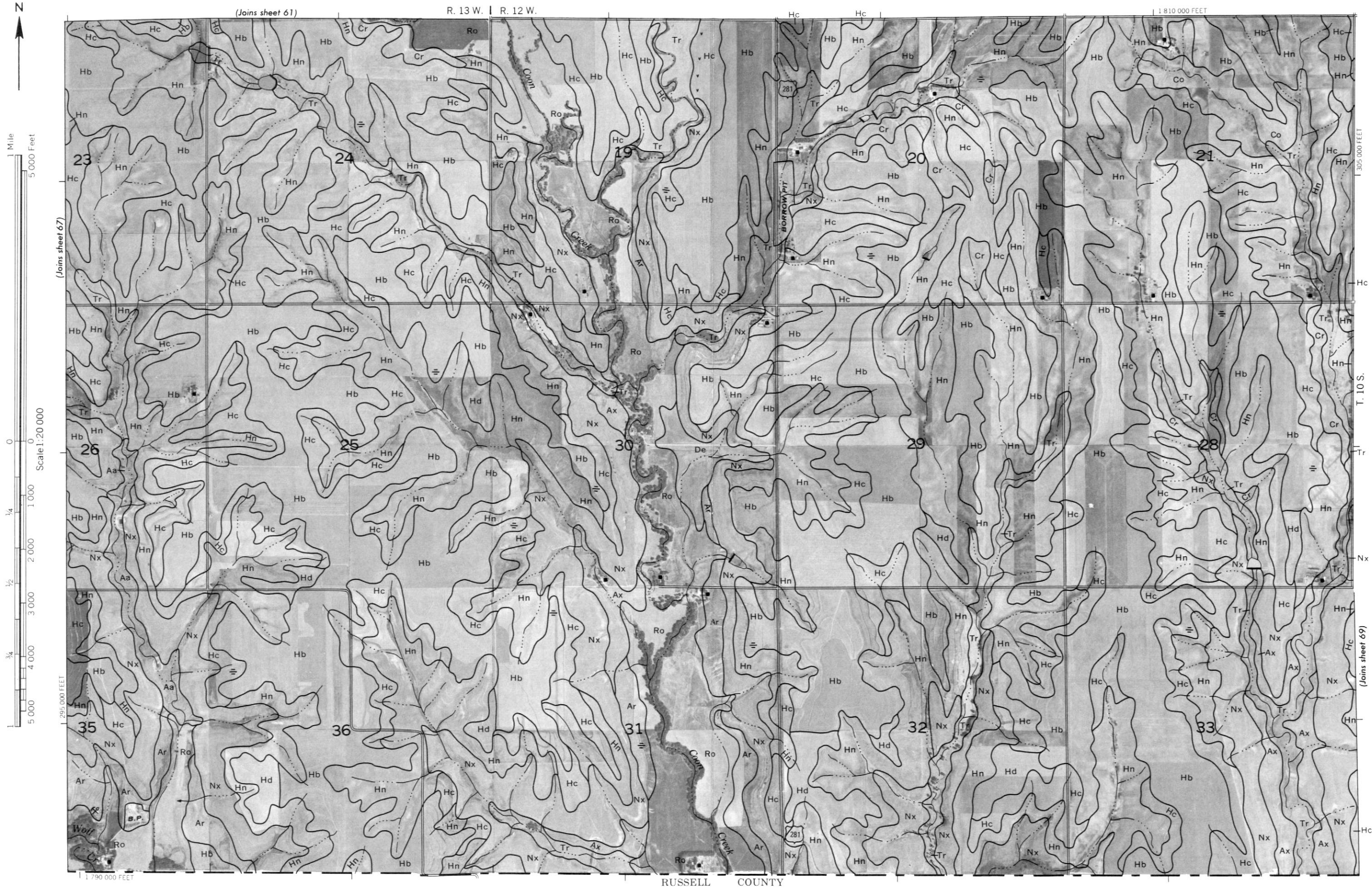


Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
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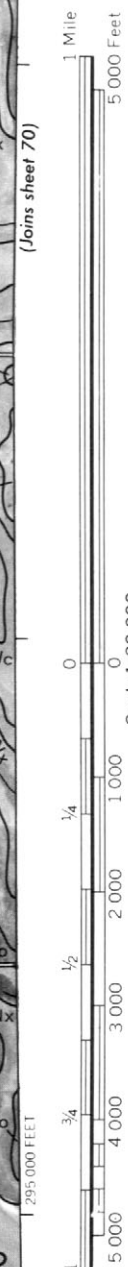
Land division corners are approximately positioned on this map.  
Photobase from 1971 aerial photography. Positions of 5 000-foot grid ticks are approximate and based on the Kansas coordinate system, north zone.  
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1 Mile



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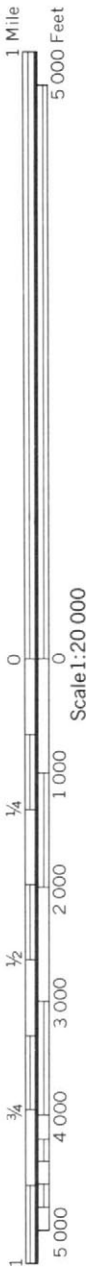
308

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311





Land division corners are approximately positioned on this map.  
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